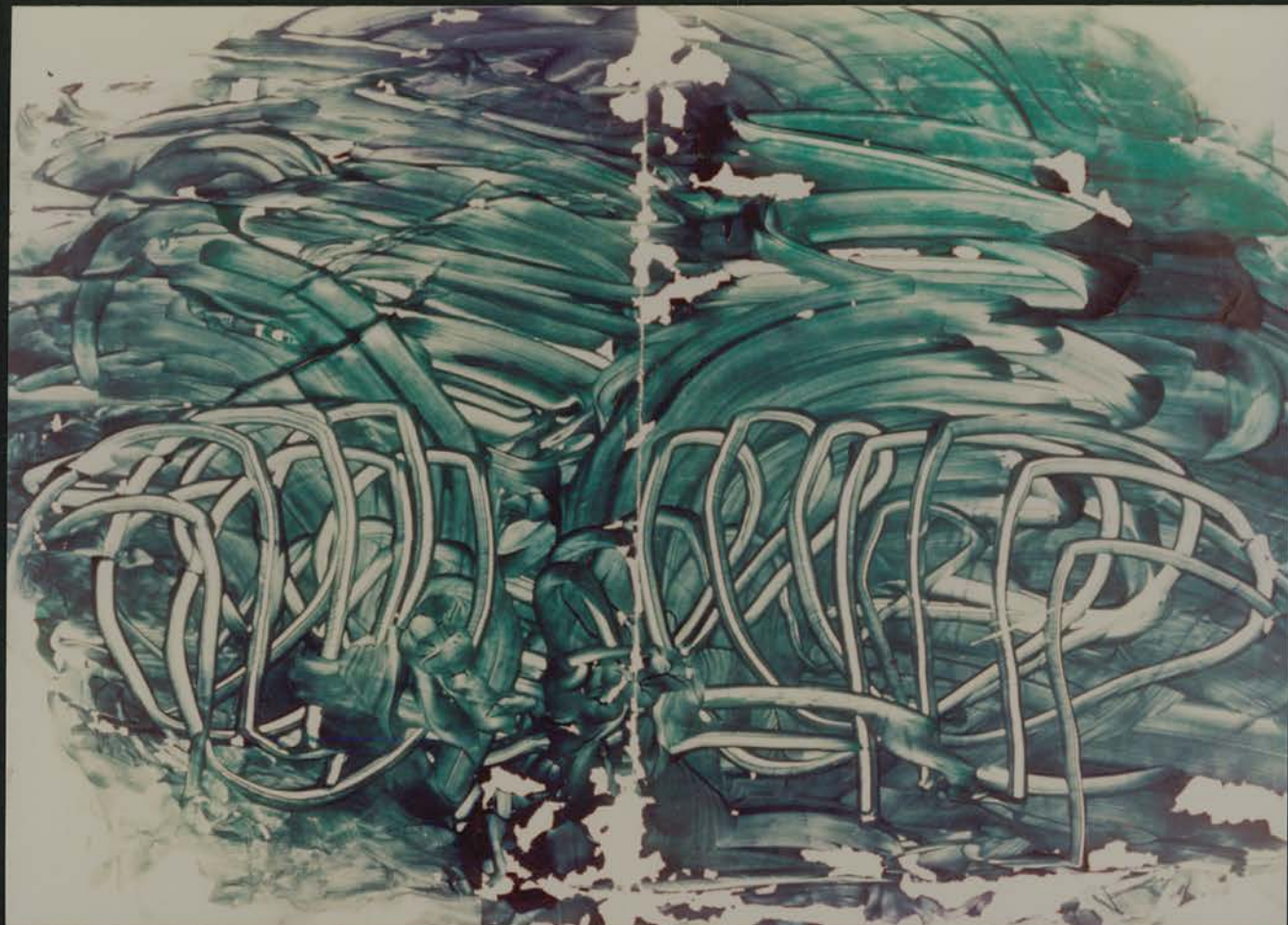


**AND THEN ON BOTH HANDS:
LATERALITIES OF YOUNG DEAF AND HEARING CHILDREN**

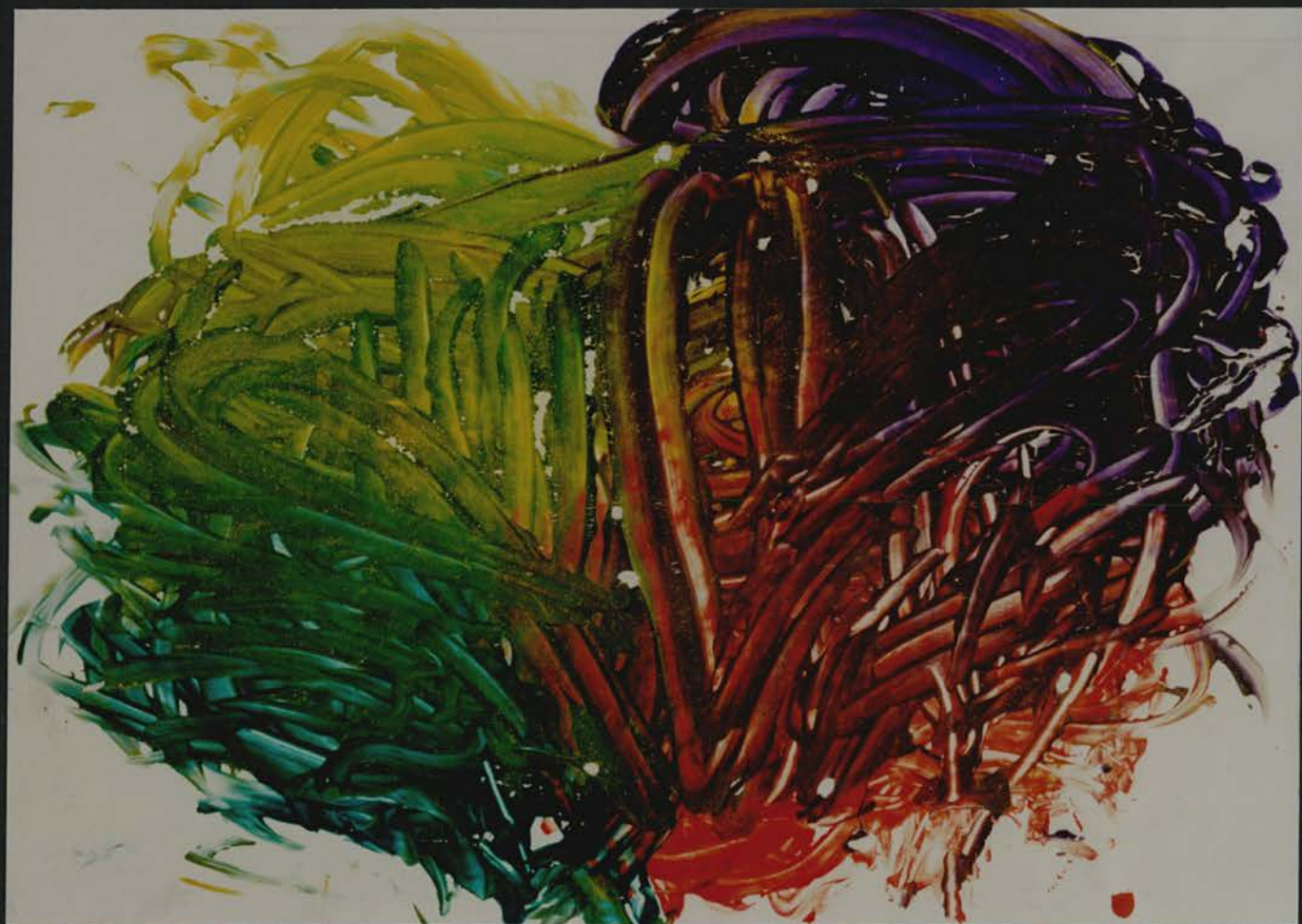
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1992





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ACKNOWLEDGMENTS

I would like to thank the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom for the Overseas Research Students Award and the councils and parents who granted permission for the children to participate in the studies.

I am also grateful to the following people:

First, the children I taught and the children I tested.

Next, my supervisors, Colwyn Trevarthen and Tom Pitcairn, for giving me the opportunity to work independently -- Colwyn also for many long-term loans of journals and books and his attempts to make my sentences make sense, Tom also for critical comments and statistics corrections;

Peter Caryl for his unofficial supervision and support;

Jennifer Wishart for her advice and encouragement;

George Montgomery for interesting discussions and much helpful information;

Bronwen Burford, Lesley Jack, and Effie Fenton for their assistance with inter-rater reliability counts;

Muriel Slade, Ann Henderson, and Margaret Aitken for their help with the videotape transcriptions;

Christine Rees and Hamish Macleod for their solutions to computer problems.

Last, and most, the two who have helped me all along and in many ways since the beginning of my interest in deafness, Kay Meadow-Orlans and Hilde Schlesinger.

With special gratitude, I dedicate my thesis to the late Donald H. Klinefelter, who made the impossible possible.

I declare that with their support, the composition of this thesis, the research reported, and all related work have been done solely by myself.

ABSTRACT

The handedness patterns, communications, and sequencing abilities of 80 deaf and hearing children from three to seven-and-a-half years old were analyzed to see what they can tell us about how children think. The children's actions and language seemed to correspond to their ability to perform a variety of sequencing tasks. Significant correlations of the sequencing task scores with age, with handedness, and with later school ratings suggest developmental progressions, and a link between functional lateralities of hands and hemispheres.

Manual specialization and coordination appear to be an expression of a mental ability to both discriminate and integrate information, to relate parts to a whole, to determine relevant details and arrange materials in a sequential order. In the first stage of development, unity and symmetry tend to prevail: Both hands are used simultaneously and with little differentiation of function; objects are matched according to a single same feature and are arranged symmetrically from the child's midline and around one central object. The second stage is characterized by duality and asymmetry: Each hand is used alternately and with equivalent frequency; differences are detected; objects are paired, and dichotomous groupings are formed. What distinguishes the final stage is plurality: Manual movements become specialized, coordinated, and continuous as a complementary system evolves in which one hand is subordinate to the other and each is assigned a specific act; several attributes of the objects are associated, and materials are placed in logical progressions.

The handedness of the children was measured along a continuum. A separate ratio was obtained for three types of contact while they were doing the sequencing tasks and for their hand, foot, and eye preferences when doing several other activities. Compared with the dominant hand use and preference of the hearing children, the oral deaf children showed more leftward and more rightward lateralization, the total communication deaf children more mixed lateralization.

On the sequencing tasks, differences between the deaf and the hearing children were related to the kind of task. When the order of events in a story book was to be recollected and when series of body movements and hand-clapping patterns were to be imitated, the deaf children approximated or exceeded the hearing children in ability. On the tasks that did not require visual memory but instead required an awareness of a logical progression of temporal and spatial sequences, the scores of the deaf children as a group were significantly lower than the scores of the hearing children. From re-test and age-adjusted scores, and individual exceptions, this general inferiority would seem to be caused more by a delay in development than by deficient capacity.

Other factors associated with success on these sequencing tasks include left-handedness, name-writing ability, and first-born status. Adverse factors, such as a hearing loss aetiology of perinatal injury, a vision abnormality, and undifferentiated mixed handedness, imply that manual and mental specializations and coordinations are necessary for learning to be optimal.

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CHAPTER 1

INTRODUCTION

...no aspect of a presentation is random or meaningless.

Beloff (1988, p. 297)

PART I. BACKGROUND INFORMATION

Observations

Children I taught at a school for the deaf in the United States, between 1975 and 1985, inspired the research reported in this thesis. Those 40 children, in their first and second years at school, taught me to appreciate the uniqueness of each individual child, to wonder at and about their achievements, and to question the ways they perceive and process information.

Certain differences between the children seemed to follow a pattern associated with differences in hemispheric dominance. Characteristics of some children were similar to what have been described as expressions of a right-hemispheric dominance, whilst other characteristics, of most of the children, reflected a more left-hemispheric mode of thinking. Specific differences I observed are summarized, and three children are described, in Appendix I, Classroom Examples.

For me as their teacher, paramount questions included the following: Why are there these radical differences between children? Why are the same children geniuses at some tasks and dunces at others? How can children, in contrast to adults, learn languages with such speed and facility yet have a short memory for specifics? For whom are these generalizations not -- or more -- true?

Of importance are the skills and deficits that seemed to defy classification. One is the reputed inability of deaf children to sequence, a claim teachers made with a headshake and sigh

of resignation. Why would deaf children, who do put on their socks before their shoes, selectively have difficulties with the sequencing tasks that are part of a school curriculum? In what ways might their hearing loss, and their dependence upon vision for receiving information and communicating, contribute to this alleged difficulty? Could sequencing difficulties relate to the persistent lower levels in deaf children's reading achievement and their errors particularly in the syntax of spoken and written English? How might these disabilities fit into the patterns observed in their performance of other tasks that also have a parts/whole and a sequential/simultaneous dimension?

Other important factors confounded explanation. One is handedness: There appeared to be no consistent pattern, except that left-handed or ambidextrous boys and a few right-handed, but not left-handed, girls excelled in the more 'right-hemispheric' operations. An unknown was whether this profile would apply collectively to deaf children more than to hearing children.

What was clear, though, was that the differences observed in the classroom (termed 'id' and 'est') were definitely not exclusive to deaf children. Analogous contrasting behaviours of hearing children are described by Fadely and Hosler (1979). They identified children whose preferred mode of thinking is right-hemispheric as 'natural' or 'Alpha' children, and those with a predominantly left-hemispheric mode as 'Theta' children. Ashton-Warner (1963) recognized qualities of Maori children that so differentiated them from the other children she taught that she adapted her teaching methods and developed 'organic' reading materials to be compatible with their own lives, learning styles and sensibilities.

Such demarcated abilities have been seen not only among young children. An English teacher of secondary-school adolescents has commented on how some of her students "find it difficult to put words together to form a simple syntactically correct sentence but are adept at rhyming words" (Rhoda MacKenzie,

personal communication). Lowenthal and Wason (1977) identified two different ways academics write (related to whether they disliked or enjoyed the process): There are those who have a detailed plan and make serial corrections of one complete draft, and there are others who originate and clarify ideas while they compose several drafts. Citing these university authors in their advice to postgraduates about how to write a thesis, Phillips and Pugh (1987) label the two types of writers as 'serialists' or 'holists'.¹

Books have been written about The Use of Lateral Thinking (de Bono 1967), The Tao of Pooh (Hoff 1982), A Right-Brained Approach to Learning (Vitale 1982), Drawing on the Right Side of the Brain (Edwards 1979), and about how right-hemispheric visualization techniques can improve sports ability (Nideffer 1985), enhance sexual pleasure (Wells 1990), and overcome cancer (Simonton, Matthews-Simonton, and Creighton 1978). Studies reported in journals and textbooks describe functions of brains that have been split and malfunctions associated with brain damage -- conditions such as agraphia, agnosia, akinesia, anarthria; aphasia, dysphasia, paraphrasia; alexia, dyslexia, paralexia; apraxia that is ideational and apraxia that is ideomotor.

From the numerous observations, what is striking is the diversity in how humans think. Whether labelled 'Alpha' or 'natural', 'organic', 'lateral', 'right-brained', 'Taoist', 'holist', or 'est', and with whichever groups this mode of thinking is associated, by whatever means these discrete cognitive processes are isolated and identified, and however many theories offer some explanations, much about this

¹An example of a 'holist' writer is Sherwood Anderson, whose fiction was criticized for lacking structure and development:

Time as a logical succession of events was Anderson's greatest difficulty in writing novels or even short stories. He got his tenses confused and carried his heroes ten years forward or back in a single paragraph. His instinct was to present everything together, as in a dream. (Cowley 1967, p. 4)

contrasting way of thinking is an enigma.

Because of the questions asked in particular about the deaf children I taught, and their resemblances with others, my research began. There have been some answers, but still more questions...

Laterality

The ultimate objective of this research was to obtain a better understanding of the cognitive processing of young children and the effects of deafness on mental development. The specific focus was to investigate the lateralities children express in the ways they use their two hands, in the words and signs they use to communicate their thoughts, and in their abilities to do sequencing tasks.

Laterality has several referents and definitions. Anatomical laterality refers to the two sides of the body: a) the structural bisymmetry of appendages (hands and arms, feet and legs), of sense organs (eyes, ears, and nares), and of the two halves of the brain; b) the neurological patterns of contralateral or ipsilateral pathways through which information is transmitted, as afference and efference, between each cerebral hemisphere and other parts of the body; c) the functional asymmetries of cerebral dominance, mediated centrally by the corpus callosum and brain stem. 'Laterality' also has a mental sense: 'Lateral thinking' is defined as "Thinking that ranges over unusual aspects of a problem or topic and often furnishes unexpected conclusions" (Longman 1984, p. 827), as "Thinking which seeks new ways of looking at a problem and does not merely proceed by logical steps from the starting-point of what is known or believed" (Chambers 1979, p. 743). In this thesis, both the physical and mental senses of laterality are considered. The research explores how young hearing and deaf children manifest asymmetries in behaviour and 'sidewise' thinking, and what these biases might mean in the children's development.

Hemispheric specialization. Our two cerebral hemispheres, and

discrete areas within each hemisphere, have somewhat different structures and different but interdependent and complementary functions. While there is a degree of reciprocity and redundancy in the mechanisms, there is also specialization and relative dominance. Dominance of one hemisphere over the other for receiving or expressing information is determined by the situation (or the kind of experimental task presented -- its degree of difficulty and novelty and the complexity of the response required) and varies according to differences among individuals regarding their possibly innate characteristics, their acquired abilities, and their transitory disposition.

In general, the left hemisphere is associated with segmental, time-ordered, analytic processing and sequential motor control, especially in language production; the right hemisphere is associated with global, simultaneous, visual perception and the process of synthesizing spatial and affective information. (For reviews, see Trevarthen 1984, Annett 1985, Beaton 1985, Springer and Deutsch 1985, and Corballis 1992.)²

Speech and language. Speech is processed predominantly in the left hemisphere by the majority of people: by about 96% of those who are right-handed and by about 70% of those who are left-handed (Rasmussen and Milner 1975, cited in Annett 1985). The left-hemispheric dominance is seen to be invariant to whatever way a language is expressed: whether the language is

²Such a dichotomous classification of functions is deceptive, and is valid only for understanding discrete operations within a complex of interactions. We are whole beings, with our own inconsistencies, our own sensibilities and histories. Yet we have two cerebral hemispheres, and use them both in ways that are at once individual and momentary and universal, in ways that are not eternal but variable and modifiable. Other simplified statements also reduce a vast literature and ignore many specific conditions that are not directly related to a deaf person's experiences and cognitions. One error may be in the localization of functions: What are referred to as left-hemispheric properties may be located within the cortex, and right-hemispheric properties within the subcortex. At present, however, there is sufficient evidence and acceptance for the terms 'left' and 'right' to be used to differentiate separate functions of psychological significance.

spoken (and is either tonal or inflectional) or whether it is visual (and is fingerspelled or signed or written -- in ideographic symbols or alphabetic letters or braille), and whether it is the language acquired first or later.³ Right-hemispheric involvement in the processing of language appears to be crucial, but minor. Its complementary contributions are linguistic nuances and are specialized more for perception than production, and for perception of words and signs that are static and isolated rather than changing within continuous utterances.⁴

The feature of language typically lateralized in the left hemisphere upon which my research is based is its sequential property. In its linearity, spoken (and written) language is differentiated from music, mathematical concepts, and spatial perceptions, as well as from the many simultaneous visual aspects of sign language and the nonverbal and paralinguistic components of spoken language (including not only 'body language' messages seen and intonations heard but also the emotions felt and transmitted by these signals) -- all features of a right-hemispheric cloisonné to the left-hemispheric substance.

Comparisons between hearing and deaf people can inform us about human cognitive processes and the specializations of each hemisphere. For instance, the studies of adult deaf aphasics reported by Kimura (1981), Bellugi and her colleagues (e.g. Bellugi, Poizner, and Klima 1983 and Poizner, Klima, and Bellugi 1987), and Lebrun (1985, Lebrun and Leleux 1986) provide evidence that brain-injured deaf and hearing adults

³Note, however, that Left-hemispheric localization for vocalization is not unique to humans: The song of chaffinches and canaries is also controlled by the left hemisphere (Nottebohm 1970 and 1980).

⁴References include Hoosain and Shiu (1989) about Cantonese Chinese and Chinese-English bilingualism; Kinsbourne and Hiscock (1983) about bilingualism in general; Corina, Vaid, and Bellugi (1992) about adult deaf and hearing signers; McGuinness (1985) about blind children and adults; Poizner (1983) about temporal variations of signs and Sperry (1990) about single words versus words in a series.

have similar skills and deficits in the production and comprehension of language (and similar visual-spatial abilities and disabilities). Furthermore, *unimpaired* hearing and deaf adults who are fluent signers have shown an asymmetric manual response while imitating signs and words (but not gestures, whether 'symbolic' or 'arbitrary'), indicating left-hemispheric lateralization specific for language -- in either a spoken or signed modality, and specifying a general linguistic basis for this lateralization (Corina et al. 1992). Another explanation for the leftward bias in cortical language mechanisms of signers is the left hemispheric specialization for programming and executing complex movements and skilled motor sequences (Lomas and Kimura 1976, Kimura 1990). An implication of these findings is that left hemispheric specialization is not confined to the auditory modality.

Questions concern those whose manual skills and language system are less well developed -- children who are severely to profoundly and prelingually deaf, as well as others in specific subgroups within a hearing population.⁵ To what extent might these children be able to assimilate auditory/verbal information better with the left hemisphere, and visual-spatial information better with the right hemisphere? How might the auditory deficit and the consequently increased visual dependence -- and any concomitants or *sequelae* of these conditions -- alter the hemispheric asymmetries during a deaf child's development? Among deaf people, might there be differential effects related not only to age but also to etiology, parental hearing status, and mode of communication?

⁵Although the incidence of deafness within the total school-age population is low (between 1/1000 and 1/2000 children, depending upon the classification criteria), approximately 15-20% of school children are thought to have experienced some degree of hearing loss (Webster 1986). Children who have had repeated attacks of otitis media and mild intermittent hearing losses have shown associated delays in development, 'underachievement', and, in particular, reading difficulties (*ibid.*).

Studies that consider relative impediments and expedients to performance when test results are interpreted and individual attainments are assessed, that examine strategies as well as capacities, and that include younger and oral deaf subjects suggest that audition might at least facilitate both linguistic competence and cortical asymmetry, and that auditory deprivation, delayed language development, and use of sign language are all factors associated with reduced cerebral asymmetries (McKeever, Hoemann, Florian, and VanDeventer 1976; Phippard 1977; others reported later). Something none of these studies, nor those cited above, exclude, and that could be very important, is the plausibility that a principal requirement for left hemispheric specialization is linguistic competence -- acquisition of a symbolic language system and fluency in communication, be it by speaking or signing.

Linguistic experiences have, indeed, been seen to make a difference in cerebral dominance:

...the quality and quantity of exposure to language itself may affect the development of lateralization. (Springer and Deutsch 1985, p. 200)

...environmental factors, particularly those related to language experience, can influence the development of cerebral specialization. ...the degree of experience with language may be positively related to the degree of left-hemisphere language dominance. (Ross 1983, p. 288)

Signs. 'Lexicon' gives a clue to the two forms in which a language can be expressed: in words or in images. Like words, signs rarely exist in isolation: They are strung together in sentences, with segments altered and elided. However, properties of a basically acoustic system for words and a basically visual system for signs "are based upon a totally different set of fundamental principles that stand irreducibly apart" (Tervoort 1978, p. 171). One of the different principles is linearity versus simultaneity: In speech, syllables and words must be sequentially concatenated; in signing, many manual-visual elements are simultaneously conflated (Studdert-Kennedy and Bellugi 1980). Distinctive

features of signs are the configuration, orientation, location, and movement of the hands -- parameters that occur simultaneously in space.

The simultaneous aspect of signs does, however, have a counterpart with spoken words. Articulation with the vocal organs involves variations of intonation and stress: volume, pitch, tempo, and duration changes. These prosodic features that are perceived auditorially also are simultaneous and inseparable. They also affect meaning (for instance by indicating a statement or a question, or implying sarcasm). However, each word is no more than a word, whereas a sign can be a sentence. Simply by changing the movement of a single sign, the meaning is altered. For example, 'look' can be signed (as it can be said) to indicate the degree of urgency, but also the direction of the movement of a sign differentiates between the subject(s) and object(s), and variations of the movement can incorporate adverbials (such as to look at something quickly or for a long time, once or repeatedly). Thus, modifications of one basic sign provide information that in speech necessitate another or other words (e.g. 'glimpse' or 'stare at' or 'ogle', "Look at *that/those/me*").

Differences between spoken and signed communications relate to the different articulatory mechanisms: of one tongue and one larynx for speech sounds but of two hands for signs.⁶ In the signed communications and pantomimes of deaf children as well as in the conversations of deaf adults, both hands will be

⁶In the standard formation of most signs, both hands are used, either with both hands active or with one hand acting upon the other. The proportions of one- and two-handed signs in American Sign Language (ASL) and in British Sign Language (BSL) are similar, although the two sign languages have different origins. Of signs listed in an ASL dictionary and in a Scottish dictionary, the percentages for the ASL signs reported in Klima and Bellugi (1979) correspond to those I determined for the BSL signs: 60% in ASL and 62% in BSL are two-handed (35% in ASL and 33% in BSL having symmetrical movements and 25% in ASL and 29% in BSL having the dominant hand act upon the other, passive 'base', hand); 40% in ASL and 38% in BSL are classified as one-handed.

seen to be active -- in multiple ways not possible in speech.

Two complete words can be signed, but cannot be said, at the same time (Levelt 1980). A child will sometimes sign 'parents' by simultaneously signing 'mommy' with one hand and 'daddy' with the other hand, or will conjoin a possessive or negative with another word, as in 'my-book' and 'not-me'.⁷ Commonly, among native signers, a sign made with one hand will serve as an index, establishing a spatial or contextual reference. While that hand is held, the other hand adds other information, such as an elaboration, a parenthetical aside, a turn-taking instruction (e.g. "Hey!" or "Wait..."), or a query (e.g. about a next letter in a fingerspelled word).⁸ Another two-handed option is redundancy: The same sign made simultaneously with both hands can signal plurality or intensity (i.e. 'several' or 'very').⁹

The versatility in signing is possible because context provides sufficient clues if one hand is used in place of two, and because only a very few signs have different meanings if signed with one or with two hands.¹⁰ Thus, most one-handed signs can be signed optionally with one -- with either -- hand or with both hands at once. Although one hand will usually be dominant, frequent hand switches have been observed in

⁷See Appendix I for other examples observed, also Bellugi and Klima (1972) or Klima and Bellugi (1979) for examples of co-articulated signs that are either unintentional errors (sign 'spoonerisms') or intentional 'witticisms' that are dramatic, poetic, or humorous.

⁸Such two-handed communications are presented in sample dialogues in the textbooks by Baker and Cokely (1980) and Cokely and Baker (1980) and in the descriptions of a deaf child's signs by Hoemann and Lucafo (1980). Rules governing the formation of signs when both hands are used simultaneously are discussed in Chapter 9.

⁹Greater redundancy is achieved when words are spoken, or mouthed, while signed, and further extensions are possible when a general word is signed while a specific word is said (e.g. combining the sign for 'place' or 'city' with the word 'Detroit' [Tervoort 1978]).

¹⁰Exceptions in ASL are 'yellow' and 'play' and these same signs in BSL, but glossed as 'perhaps' and 'party' (the latter sign identical but two-handed). Similarly, in BSL, 'Scottish' and 'duck' are differentiated only by duplication in the latter sign, executed with both arms.

children's signing (Virginia Swisher, personal communication).¹¹ Young children also will use both hands, duplicating one-handed signs. Preschoolers are reported both to change one-handed signs into two-handed signs more frequently than the reverse and to be able to recall two-handed signs better than one-handed signs (Langlois 1982, cited in Doherty 1985). In instruction, the option to use both hands at once can be exploited. For example, addition and subtraction problems can be clarified when the numbers from one to ten are signed with one hand operating on the other that is static (as when adding three to five by changing a '5' hand to a '6, 7, 8' formation when contacting each finger of the '3' hand -- something else simpler done than said!).

The contrast between the simultaneous dimensions of signs and the segmental, sequential properties of speech -- even independent of an effect of auditory deprivation -- could well be related to differences in perceptions and cognitions:

Hearing children develop a bias toward processing sequential information in general which allows them to understand the sequential information inherent in English. Deaf children, at the same age, do not appear to have developed a similar bias. (Gibson and Segalowitz 1986, p. 218)

For deaf people, speech not only is beneficial in communicating with hearing people but also might be necessary for certain types of thinking, for the development of internal language, and for reading skills. Pertinent quotations include the following:

...different groups of deaf children may resort to different strategies for solving cognitive problems

¹¹See Frishberg (1985) for a description of deaf and hearing signers' dominance reversals and the different grammatical structures in which they tend to occur; also, Bonvillian, Orlansky, and Garland (1982) about the high incidence of left-handed fingerspelling among deaf high school and college students (reported by 35.5% as equal to or greater than right-handed fingerspelling, whereas only 13% were classified as having left-handed tendencies for other actions).

according to their environmental conditioning. (Fundudis, Kolvin, and Garside 1979, p. 133)

The majority of children with severe to profound hearing losses have either no internal speech or only enough for the simplest mechanical cognitive operations. (Conrad 1979, p. 245)

...characteristics of a language based initially on a visual system (including speech reading and sign language) could influence the reading process directly. ...If the deaf are, in fact, using the right hemisphere to mediate the reading process, it may place an upper limit on their reading ability. (Gibson and Segalowitz 1986, pp. 219 and 222)

...the grammatical structure of the text must not be too alien to the grammatical forms of the child's speech. (Donaldson 1984, p. 98)

The deaf child is likely to be exposed in print to both vocabulary and syntax that are not part of his existing linguistic competence. (Wood, Wood, Griffiths, and Howarth 1986, p. 104)

...a crucial component of the early auditory environment appears to be the ability to attend to sequential information. The normal bias towards a left-hemisphere dominance for linguistic tasks may reflect the salience of sequential information, which is inherent in speech and verbal language. When a child is not exposed to this critical component in the first few years of life, or prenatally, the appropriate neural substrate for language may not develop, and this in turn may not only interfere with the development of a verbal language but also the development of advanced reading skills. Thus, early developmental history appears to have a profound impact on the development of brain lateralization. (Gibson 1988, p. 603)

What could seem to be a solution is a combination of modalities: signing while speaking, i.e. incorporating signs

into the structure of the spoken language.¹² Socially, the sign language systems would accommodate the hearing parents' oral language with the deaf children's proclivity for signs, possibly without compromising one for the other or requiring exclusive conformity, and would respect the needs and strengths of the parents and the children. Linguistically, exposure to English structure, and fingerspelling, in signed communications could have benefits not only for thinking but also later for reading. Whatever would expedite reading competence ought to be granted merit and priority, especially since it is known that literacy enhances language development (Grieve 1990) and can facilitate speech development (Wood et al. 1986), and that for some children language becomes meaningful only when it is read (Hart 1963).¹³

Concerning the pragmatics of speech, and the combination of speech with signs, decisions vary and doubts remain in at least four key related issues.

¹²A distinction to be made is between languages that are 'caught' versus 'taught' (see Wood et al. 1986): Sign languages are 'caught' -- ubiquitously, whenever deaf people are together (Schlesinger and Namir 1978), and are created by deaf children whose parents do not sign to them (Goldin-Meadow and Mylander 1984); oral skills for deaf children and sign language systems are taught. Sign language systems are inventions that have been devised as a manual means of visually representing a spoken language and serve as a complement to the partial information received through impaired audition and from speechread segments. Most incorporate signs from the sign languages of deaf people, but their lexicons include function words, and in syntax and morphology they conform to the spoken languages. Manually (en)coded English (MCE) systems -- such as Signed English (SE), Seeing Essential English (SEE I), Signing Exact English (SEE II), Linguistics of Visual English (LOVE), and the Paget-Gorman Sign System (PGSS) -- differ in the rules upon which the signs have been adapted, what affixes have been contrived, whether signs are initialized, etc. (Quigley and Paul 1984). When the signs are produced simultaneously with speech and are supplemented with amplification, speechreading, fingerspelling, gestures and mimes, facial expressions and body positions, they constitute 'total communication', the method and philosophy of combining communication modes to maximize all auditory and visual cues available for receptive and expressive communication.

¹³In different media, words have differential perceptual qualities. While words when spoken (and generally when signed) are transient and fleeting, words in print are static and segmentable: "...the printed word, being enduring, allows the child the opportunity to stop and think" (Grieve 1990, p. 160).

1. Is there an order in which oral-aural and manual skills should be taught, and when should a signed system be introduced (Conrad 1976, Evans 1982)?
2. How well do the two modes synchronize, and how well do children simultaneously process visual and auditory information? Consequences of decrements or incompatibilities could be a loss of rhythm or a 'pidgin' blend of English and sign language (Nicholas 1976, Bonvillian and Nelson 1978, Kluwin 1981, Ling 1984). If there are some children, however few, who have difficulties with multiple stimuli, what provisions, alterations, or alternatives would be required so their progress is not jeopardized?
3. If there is less activation of the speech mechanisms, what effects of atrophy might be detrimental to learning (Arnold 1983)? And if mental, as well as manual, activation is more bilateral while signing, are the consequences more positive or negative?
4. Is speech a catalyst or a necessity for effective development of internal language and the conceptualizations thought to depend upon a language system -- especially when audition is impaired? If language competence, more than either speech or audition, is a prerequisite in the development of thinking, could sign language fluency be as effective as fluency in a spoken language (Ross 1983)? And is there a time proviso, stipulating acquisition of language -- any language -- before the age of, say, five?¹⁴ The possibility that reading can reinforce a linear, analytic processing ability would be encouraging were it not necessary first, before printed text can be meaningful, to have an adequate comprehension of language.

With these conundrums of mind in mind, the lateralities that deaf and hearing children have shown on tests related to the sequencing tasks in the thesis studies are reported in Part Two, Research Objectives. First, the link between hands and hemispheres is discussed.

Hands and hemispheres. The following statements about handedness are generally accepted as facts: a) Each hand is controlled in its refined coordinations by the contralateral

¹⁴Conrad (1971) has proposed that it is about age five when the fluent overt speech of most hearing children functions in a way for internal ('covert') speech and a verbal code to be used for purposes of directing actions and mediating experiences.

hemisphere; b) left-handers are less strongly lateralized than right-handers; c) there are fluctuations and different stages in the development of manual (and mental) specializations; and d) dominance preference is in part hereditary/innate and in part influenced by environmental conditions.

The predominant right-handedness of humans is unparalleled in the animal kingdom. While approximately 90% of all people in most cultures are right-handed (Hicks and Kinsbourne 1978, Porac and Coren 1981), comparable specialization in animals is less evident and less consistent. A foot or paw preference of some individual animals (e.g. cats, rats, and mice) appears to have no consistent population bias: As many individuals will have a left as a right preference (references cited in Porac and Coren 1981, Corballis 1983, Springer and Deutsch 1985). An exception (reported in Corballis 1983) may be some species of parrots that use the left foot preferentially for manipulations and the right foot for support. Also, hand preference has been shown in some non-human primates: Old world monkeys (primarily macaques) have a right-hand preference for fine manipulations and a left-hand preference for visually guided reaching (studies reviewed by MacNeilage, Studdert-Kennedy, and Lindblom 1987). These functional manual differentiations, along with structural similarities (e.g. the prehensile hand, the opposable thumb, and bipedalism), suggest a link with human conditions.¹⁵

From their numerous studies, Porac and Coren (1981) report consistently higher correlations of paired limb (hand and foot) preferences than of paired sensory (eye and ear) preferences. Brain (1945) reports studies showing hemisphere-hand correlations to be close, but hemisphere-eye

¹⁵In another review of primate studies (Chevalier-Skolnikoff 1989), the behaviours of Cebus monkeys and chimpanzees were found to be analogous with stages of human infant development: Their use of tools and coordinated manipulative skills were associated with sensorimotor intelligence, i.e. abilities demonstrating experimentation, intentionality, and insightful solutions.

(also hand-eye) correlations to be at a level of chance. An anatomical explanation is that information is available to both hemispheres through the bilateral pathways from the eye and ear, whereas each hemisphere has a much stronger direct control of the contralateral hands and feet. Therefore, patterns of how the hands are used can strongly implicate the controlling hemisphere -- particularly if several differentiated manual functions are examined -- and by observational procedures which are less intrusive than the procedures required for determining eye and ear preferences.

Progressions in the development of handedness. Gesell and Ames (1947) found individual differences and fluctuations in the handedness of seven children filmed from infancy to the age of ten. The children's contacts with and manipulations of objects shifted from variable use of their nondominant hand during the first year to bilaterality at one-and-a-half years, to dominance at two years, back to bilaterality between two-and-a-half and three or three-and-a-half years, then to increasing unilateral dominance (with less or transient use of the passive hand) from four to ten years.¹⁶ Reviewing this and other studies, Corballis (1983) estimated that hand preference is stabilized when a child is about eight years old.

¹⁶Gesell and Ames (1947, p. 165) observed that bilaterality occurred in three ways:

- (1) Simultaneous bilateral approach and manipulation; (2) Passive hand held ['expectant and poised'] ready to come in as a helping hand. In almost no case does passive hand remain down by the side. (3) Use of one hand in one part of examination and of the other at a later time in the examination...

They also noted that bilateral movements would recur "when the situation is very difficult or involves several objects simultaneously" (p. 166).

As with handedness, they found "an unmistakable predilection toward rightward orientation" in the tonic neck reflex of infants, a preference that was predictive of handedness in 14 of 19 cases (p. 171). (Both neonatal head-turning preferences and later handedness are reported to have significant positive correlations with the thumb-sucking preference of the foetus [Hepper, Shahidullah, and White 1991].)

The emergence of unimanual and specialized bimanual preferences has been seen to relate to stages of speech development (Ramsay 1980): One-handed repetitive banging of objects appears to coincide with one-syllable repetitive babbling (when an infant is about six months old); two-handed differentiated skills and two-syllable utterances seem to emerge around the same time (about six months later). Another six months later, at the time words are combined, bimanual differentiation becomes complete: Each hand independently performs a separate sequential action (Ramsay and Weber 1986).

Lenneberg (1967) suggests further concomitants in the acquisition of motor skills and the acquisition of language: an ability to sit without props corresponding to the babbling stage; first steps to first words (when about one year of age); two-footed jumps to utterances of at least two words (about two-and-a-half years); tiptoeing, riding a tricycle, and alternating feet on stairs to utterances that are grammatically complex and like adults' colloquial speech (about three years). Maturation of the brain (regarding structural growth, biochemical and neurophysiological changes) also has periods associated with milestones in language development: By the second year of life, when language emerges, the rapid rate of cerebral maturation ceases; at puberty, when facility to acquire a primary language becomes inhibited, cerebral lateralization is established (*ibid.*)¹⁷ These coincidental stages can be interpreted as corollaries and congruencies, with brain maturation not necessarily causing but constituting prerequisite and limiting factors to motor developments and the acquisition of speech and language.

Another developmental association is with

¹⁷Epstein's (1986) research and review of data (from brain weight, head circumference, EEG activity, and cortical thickness measurements) indicate developmental stages in the rate of human brain growth, with the first two significant peaks about the age of three and seven years (and later, about age 11 for females and 15 for males).

stammering/stuttering. There are reports that these speech spasms occur particularly at two times: between age two and three, when a child begins to combine words into phrases and sentences and when his movements are characteristically bimanual; and between six and eight years, when a child is beginning to read and write (Orton 1937, Burt 1958).

In Kendon's (1986) summary of the findings of independent studies about the relationship between gestures and speech, he states that with age there appears to be an increase in gesticulation and in the degree to which the two modalities converge and become coordinated. However, steps towards this coordination, seen in the communications of adults, are said to begin first in a separation of each form of expression, as in the pantomimes and elaborate enactments of whole scenes when children younger than eight do not relate their words and their gestures. Then at a stage during adolescence, a shift is seen in the precision and specialization of expression "towards a use of gesture that is more selective and which is much more coordinated with what is being said in words" (p.36). Thus, original differences evolve into a verbal-gestural unity.

Hemisphericity and handedness studies. In many studies, researchers quantify the responses made with one hand versus the other as behavioural evidence of how the two hemispheres function.^{18 19}

¹⁸Similarly, with a tachistoscopic procedure, what is perceived in one-half of a visual field is an indication of activation of the opposite hemisphere; or with dichotic listening tasks, when conflicting information is simultaneously presented to each ear, more correct responses suggest dominance of the hemisphere contralateral to the ear that received the stimulus.

¹⁹In contrast to these indirect measures that infer mechanisms from overt responses, EEG tests that measure neuronal activity (e.g. coherence and amplitude asymmetry) within the cerebral cortex of intact subjects, including children from the age of five, are direct measures that provide evidence of aspects of cerebral functioning, of internal processes which are intermediate between input and output (see Chapter 9).

For example, in some studies, functional dominance of a hemisphere is inferred if an activity, such as speaking, causes interference in the functioning of the contralateral hand, as when finger-tapping with the right hand is disrupted: in this situation implicating left hemispheric dominance for speech processing. O'Leary (1980) studied manual movements to investigate the developmental increase in efficiency of transferring information from one hemisphere to the other (as an indication of continual myelination of the corpus callosum). His observations were of when five- to 10-year-old children, without the aid of vision, could repeat with one hand what had been 'learned' by the other (e.g. to identify a same object, to repeat a same movement, or replicate a previously perceived pattern). Only a few researchers, however, have looked more directly at how humans use their hands, or at differential actions of each hand.

McNeill (1985a, 1985b, 1992) is a proponent of the idea that gestures and speech are comparable and complementary. He believes both are "the overt products of the same internal processes" (1985a, p. 350); that, as parts of the same psychological structures, they function in parallel, share a computational stage, are synthesized and synchronized. (He also considers that opposite kinds of thinking -- both syntactic and imagistic thinking -- are coordinated.) In his view, gestures (whether 'iconic' or 'metaphoric') are 'thoughts in action' and are an integral part of communications, providing 'metalinguistic commentary' and contributing essentially, not superfluously, to the meanings of communications.

Montessori also considered that "mind and movement are parts of the same entity" (1967a, p. 142). Writing about the importance and power of the hand, she says that hands are 'the instruments of man's intelligence' (ibid, p. 27), 'the executive organs of the mind' (1983, p. 80); that not only do "the hands of man express his thought" (1967a, p. 150) but also "in the subconsciousness of humanity the hand is felt to express the inner 'I'" (1983, p. 81). She saw in a child's

movements when walking, speaking, and, most especially, when using his hands the often unhonoured need for spontaneity and choice -- execution without repression, and recognized the need for coordination, balance, order, unity, and rhythm. These integrations of movements with the child's 'inner psyche' or 'ego' she considered essential to a child's development and sense of dignity, and warned that without such coordinations there can be negative consequences, or at least fewer benefits:

...the child's intelligence can develop to a certain level without the help of his hand. But if it develops with his hand, then the level it reaches is higher, and the child's character is stronger. (1967a, p. 152)²⁰

In experiments with right-handed and left-handed adults, Kimura (1973a and 1973b) has specified that gestures are controlled by the same hemisphere that controls speech. She found increased frequencies and asymmetries in the hand used to gesture while the subjects were speaking, but not while they were humming or silently doing verbal or nonverbal tasks. Gestures ('free movements') were most frequently made with the right hand by right-handed people and with the left hand by

²⁰Others have also held hands in high regard: Not only Shakespeare (1970) realized "there was speech in their dumbness, language in their very gesture." In Cox's (1978, p. 21) estimation, "The hand probably yields more information per square centimetre than any other part of the body." Hewes (1976) believes gestures to be 'a primordial form of language', having not only antecedence to but also priority over speech. Sorell (1968) quotes Kant as saying the hand is 'the outside brain of man' (pp. xix and 33), Julian Huxley that "in man alone is the hand perfectly coordinated with the brain" (p. 37), Einstein that the hands are 'silent but not inarticulate' (p. xix), and Montaigne about the expressions of hands:

Behold the hands, how they promise, conjure, appeal, menace, pray, supplicate, refuse, beckon, interrogate, admire, confess, cringe, instruct, command, mock and what not besides, with a variation and multiplication of variation which makes the tongue envious." (p. xvii)

left-handed people.²¹

The probability of a right-handed gestural bias of right-handers when speaking was confirmed in a study by Dalby, Gibson, Grossi, and Schneider (1980) from their more 'naturalistic' observations of University professors while lecturing and students while conversing in pairs. Likewise, in Ingram's (1975a and 1975b) study of right-handed children between the ages of three and five, significantly more 'gesture-like movements' were made with the right hand than with the left hand or with both hands while the children were talking. However, unlike adults (e.g. Kimura 1973a), the children's self-touching movements were made significantly most frequently with both hands, and for the children there was no relationship between lateralization of speech and lateralization of movements while speaking. These results were thought to be further evidence that "speech functions are more bilaterally organized in the child than in the adult" (1975a, p. 100).

The study by Hampson and Kimura (1984) is the most pertinent to my research. Their experiment examined how lateralized hemispheric activity can influence *spontaneous* hand movements *during task performance*. Right-handed adults manipulated blocks to form either words or shape patterns. During the verbal tasks, the proportion of right-handed task-directed

²¹A point Kimura (1973b) does not make but that is evident in the data presented is that right-handers and left-handers were alike in their high incidence of lateralized gestures *when the hemisphere controlling speech was also the hemisphere presumably controlling the hands* (i.e. the left hemisphere for all the right-handed subjects and the right hemisphere for 32% of the left-handed subjects). The group that deviated (the other left-handers), by having a comparable number of left- and right-handed gestures, had incompatible hemispheric dominances (the left for speech but the right for hands). Examination of this group could be important since her general conclusion was that "the pattern of asymmetry in left-handers is less exclusively unilateral than in right-handers" (ibid., p. 51). Additional information that could help explain the differences among the left-handers is not available: The group of ambidextrous subjects was not isolated, but was included with the left-handers, and the data for *bimanual* movements were not analyzed (or presented in the 1973b report). This ambiguity is mentioned because it is relevant to my research results (see Chapter 9).

movements increased, and during the nonverbal tasks, the proportion of left-handed movements increased, with the differences statistically significant for each in comparison with the other and for each in comparison with a neutral baseline task. Although both hands were active during the constructions, relative ambidexterity was shown in the mean handedness ratios only, and consistently, for the 'auxiliary' (stabilizing or adjusting) movements and during the nonverbal 'spatial' tasks. The systematic asymmetric changes in hand use were interpreted as reflecting variable hemispheric involvement depending upon the different cognitive demands of the two types of tasks.²²

The last, and most recent, handedness studies to be reported are several by Annett in which the subjects were primary schoolchildren (from five to 11 years old, i.e. just older than the children studied by Ingram). Annett compared the children's hand preferences and skills, and implicit brain functions, with scores on tests assessing different intellectual abilities. Children at the extremes of a handedness continuum were seen to have specific deficits -- interpreted as higher risks for learning. On one test of intelligence (a picture vocabulary test) and on a word-reading test, the poorer scorers tended to be at both the left and right extremes (Annett 1990, Annett and Manning 1990a). On another intelligence test (Raven's Coloured Progressive Matrices), on an English test, and on subtests of a standardized educational test, scores were lower for the more consistently and strongly right-handed children (Annett and Manning 1989, Annett 1990); and on an arithmetic test, ability

²²Features of this study which differ from the other Canadian studies (of Kimura and Ingram) and the study of Dalby et al. include a) the use of videotape to record the sessions, b) the calculation of a ratio to determine relative hand use, and c) an identification and analysis of (19) different types of hand movement. As in Kimura's other studies (1973a and 1973b), simultaneous bimanual movements were excluded from the statistical analyses. Accuracy scores were reported only as they were differentiated for the male and female subjects.

declined progressively as dextrality (both right-hand skill and left-hand weakness) increased (Annett and Manning 1990b). On the other hand, skilful right-hand use, and presumed left-hemispheric processing, was associated with better scores on two tests of phonological processing: identifying spoken non-rhyming from rhyming words and indicating the order in which series of four words were heard; there was no hand skill difference on a test of homophone comprehension -- selecting the words (from homophone pairs on a printed list) that made sense in spoken sentences (Annett 1992).

What no one to my knowledge has yet investigated is the direct relationship that might exist between specific actions of each hand (or of both hands together) when in contact with test materials and the subject's performance on those tests.

PART II. RESEARCH OBJECTIVES

From the research of others, it seemed that a possible consequence of the differences and deprivations in the linguistic and social experiences of deaf children could be an arrest in development: a prolongation of a more 'natural', right hemispheric, mode of thinking and functioning, with delayed progression to a more language-related and socially codified, left hemispheric, mode, and finally to integration of the two.

How to determine a cognitive stage, and differentiate the skills of hearing and deaf children, was decided by what others (e.g. Piaget 1959 and Feuerstein 1980) consider to be an indicator of higher thought processes and reasoning abilities: an awareness of interrelationships. Sequencing tasks, consisting of at least two parts, demand perceptions of relationships. Furthermore, different types of sequencing tasks could be designed to emphasize different types of relationships, e.g. spatial versus temporal, and to depend in different degrees upon visual or verbal abilities. They might therefore provide information about left- and right-hemispheric processing in young children.

Relevant Test Results

The reasoning abilities and visual/verbal aptitudes of deaf children have long been a subject of enquiry. Influences of culture and communication that have been seen to affect test results are discussed separately, in Appendix D. Other factors that could be expected to contribute to cognitive functioning and to relate to test results include different degrees of 'concreteness' or abstraction and conceptualization required for successful performance, the demands of simultaneous perception relative to sequential cognition, and the possible facilitation of internal verbalization.

Hiskey (1956) reported differences in 'perceptual and conceptual functioning and reasoning' between deaf and hearing children based upon comparisons of their scores on the

Hiskey-Nebraska Test of Learning Aptitude, a test he purports is a valid measure of intelligence. The deaf children scored below the hearing children at each age level (from four to 10 years, measured in one-half years) on seven of the 10 subtests on which their scores were compared. On the other three subtests, they were not ahead until the age of six-and-a-half (on one) or eight (on two); thus, on no subtest were they ahead at all age levels, whereas the hearing children were continuously ahead on five subtests.²³ Hiskey's impression was that the hearing children were advantaged by having had their instructions verbal rather than pantomimed, and by appearing to verbalize to themselves while doing some items. Information not provided in this report, e.g. of the performances of individual deaf children and the aetiologies and degrees of their hearing losses, added to an examination into the types of requirements of each subtest, could also help explain the only slight superiorities of only older deaf children on this test.

Results of tests designed to investigate deaf children's memory of visual information suggest (as do three of Hiskey's subtests) that when sequential patterns are to be recalled immediately, the performance of deaf children is inferior to the performance of hearing children.

In another early study, Blair (1957) found that deaf children between the ages of 7:6 and 12:6 collectively (and regardless of the aetiology of their hearing losses -- whether endogenous, exogenous, or undetermined) were able to imitate tapping movements and reproduce design patterns significantly better than the hearing children tested and to recall locations of objects slightly, but insignificantly, better.

²³According to Hiskey's tabulations, the mean scores for the deaf children were ahead of the norms for hearing children five times by one-half year and only once by one year, while the scores of hearing children surpassed those of the deaf children 30 times by one-half year, 14 times by one year, and an additional eight times by more than one year -- even although the age-equivalent scores were determined by separate standardizations.

However, differences of greatest significance were in the memory span tests -- tests construed to possibly involve "a relatively abstract type of mental process ... the mental integration of a series of discrete yet related units into a meaningful sequence" (p. 260). When pointing to the spans of digits, pictures, and dominoes in the exact order of presentation, the deaf children remembered far fewer and shorter spans than the hearing children. Interestingly, the lowest mean scores for the deaf children but the highest mean scores for the hearing children were on reproducing digits in a forward order. Also, each memory span test correlated higher than the other memory tests with reading achievement scores on three subtests administered to the older deaf children; i.e., the specific memory span difficulties of the deaf children were those most related to reading.

Withrow (1968) reported that hearing and deaf children were similar in their abilities to immediately recall three types of visual stimuli when presented simultaneously, but that the hearing children as a group were significantly superior in recalling the stimuli when presented in a successive sequence. For both the hearing group and the group of deaf children taught orally, the grand pooled mean scores on the sequential task were higher than on the simultaneous task (with the difference statistically significant for the hearing children), whereas the scores were the same on the sequential and simultaneous tasks for the other two groups of deaf children -- those who were identified as having language-learning difficulties (and were educated in a special speech pathology division) and those who communicated manually at school and at home and had deaf parents or older deaf

siblings.²⁴ The differences were accounted for by a possible practice effect of different experiences: Through their oral-aural language, the hearing children were assumed to have had more experience, hence expertise, in processing and coding rapid time sequences.

Rhythmic sequence is one of the major dimensions of spoken language. Phonemes, words, phrases, and sentences compose language units for which the perception of the temporal sequences aids in determining symbolic meaning. (ibid., p. 33)

A verbal, successive, coding system may be less functional for a deaf child. Through his experiences of having inadequate auditory reception and a reliance upon vision, he may acquire a language, and coding, system based instead, or more, upon global and simultaneous visual perceptions. Because he may require additional practice in interpreting temporal visual symbols, Withrow recommends that visual materials emphasizing temporal cues and time-space ordered patterns be developed and used extensively in classrooms for deaf children.

More recently, using short-term-memory tests, O'Connor and Hermelin have explored the visual strategies of hearing and deaf children. In one of their digit recall experiments, hearing children reported the temporal order of items five times more frequently than the spatial order, in contrast to the deaf children who reported the spatial order eight times more frequently (O'Connor and Hermelin 1973). In other experiments also using digits, when asked to report the 'middle' digit in series of three-digit displays, the hearing

²⁴With each method of presentation, the children in all four groups were alike in recalling the silhouettes of familiar objects with least difficulty, of familiar geometric shapes with greater difficulty, and of the arbitrary forms with greatest difficulty. Other factors adversely affecting recall for all were increased items per trial and increased rate of presentation, except that by groups, the manual deaf children appeared to excel in the longest, six-item, trials with stimuli presented sequentially at the slowest rate, of one form per second -- approximately the rate at which fingerspelling sequences are said to be discriminated. (The ages of the children, although not mentioned, can be approximated from their being expected to understand the 'Look' signal before each trial and not to know the name for the pentagon or hexagon.)

children again gave temporal responses -- by naming the second digit that had appeared, and the deaf children gave spatial responses -- by naming the digit that had been in the central position; similarly, hearing children tended to recall more items appearing successively in the same place on one screen than in spatially different places, from left to right on eight separate screens (with the difference statistically significant for the forward, but not the backward, recall); however, deaf children's recall (both forwards and backwards) was more accurate when the presentation order was spatially as well as temporally differentiated (Hermelin and O'Connor 1975a and 1975b). With letters as the visual stimuli, hearing children recalled series equally well whether reporting the order from the first or from the last item presented; the deaf children were significantly superior in the backwards order -- versus the forward order and versus the hearing children (O'Connor and Hermelin 1976). An explanation offered is the possible use of different memory codes: In reversed recall, a recency effect, as well as a primacy effect, would be an advantage were a visual code used (i.e. by the deaf children), but not if a verbal-acoustic memory code were used (i.e. by the hearing children).

Several studies by Kelly and Tomlinson-Keasey also support the thesis that

...the limited accessibility to auditory symbols during the prelinguistic years, yields an information processing system that is significantly and systematically different from that of hearing children. (Tomlinson-Keasey and Kelly 1978, p. 455)

In one investigation (Kelly and Tomlinson-Keasey 1976), pictures and words of familiar items were presented visually and verbally in sets of three to 11 deaf and 11 hearing children between the ages of four and six-and-a-half. Recall was tested by how well the children were able to select and to sequence cards under four conditions: with the cards corresponding to the stimuli either in the same mode (picture-to-picture or word-to-word) or in a different mode (picture-to-word or word-to-picture). Mean scores for the

deaf and the hearing children were significantly higher on the recognition than the sequencing phase and on both phases were highest in the picture-to-picture mode. The groups did not differ significantly in their ability to recall the sequence of each item, but did differ in two other comparisons: Only the group of deaf children performed significantly better in the two same modes than in the two different modes, and only they showed no significant difference in their picture-to-picture and word-to-word recognition. (The word-to-word mode was the one mode in which the deaf children had higher mean scores than the hearing children, for both recognizing and sequencing the items.) The differences were interpreted as suggesting that deaf children may be less able than hearing children to transform information between sensory modalities by using a dual-code, visual and verbal, system for processing visual information and for developing symbolic relationships.²⁵

Tests with pictures as stimuli. Pictures, presented singly or in series, have a long history in the testing of children's intelligence.²⁶ In 1889, deaf children were classified by Greenberger as 'feeble-minded' or 'intelligent' depending upon their either 'apathetic' or 'interested' responses to picture books (Hiskey 1966). Binet and Simon (1980) found three different intellectual levels characterized by the types of children's replies to their 'presentation of a picture' test:

²⁵In another study, when using a tachistoscopic procedure to examine hemispheric laterality, Kelly and Tomlinson-Keasey (1977) found that older elementary-school-age hearing-impaired children also appeared to process both word and picture stimuli similarly, as visual images. Their 'yes-match' and 'no-match' decisions about stimulus pairs of high- and low-image words or abstract and concrete pictures were with one exception faster for the stimuli presented to the right than to the left hemisphere. However, the differences were statistically significant only for the matched high-image words, and there was a large variance among the subjects -- suggesting a general lack of hemispheric specialization along with a slight right-hemispheric propensity.

²⁶To assess written language development and to diagnose disabilities (of hearing and hearing-impaired children and adults), just one picture is used Myklebust's (1965) Picture Story Language Test.

the first by enumeration, with no connections established between the people and objects named; the second by description; and the third by interpretation, with conjectures and comments about causes and emotions. About this test, one of the 30 in their 1908 scale, they state:

Very few tests yield so much information as this one. If we add that this test is one which pleases young children the most, and succeeds in overcoming the obstinate silence of the very smallest ones, we are justified in concluding that we have found here, by chance, a test of exceptional value. We place it above all the others, and if we were obliged to retain only one, we should not hesitate to select this one. (p. 189)²⁷

Tasks devised by Piaget and Wechsler were adapted by Kaufman and Kaufman (1983) in the 'Photo Series' subtest of the K-ABC (Kaufman Assessment Battery for Children). Although designed to measure sequential processing, this subtest was later placed in the Simultaneous Processing Scale, as it was found to require not only an ordering of the visual stimuli but also "an appreciation of the holistic placement of each stimulus on a time line" (p. 49).^{28 29} Correlations of the Photo Series scores were the highest of the eight K-ABC Processing subtests

²⁷See Binet and Simon (1910) for a quaint description of their interviews and investigation into results of the oral education of 'deaf-mutes' in Paris.

²⁸Both the Simultaneous and the Sequential Processing Scales are differentiated from the Achievement Scale of the Battery in order to distinguish problem solving abilities, or process (defined as 'intelligence'), from knowledge of facts, or content (defined as 'achievement'). (Others use the term 'fluid' for processing abilities and 'crystallized' for achievement [Blennerhassett 1990].) How the stimuli are mentally manipulated determined whether a task was categorized as Sequential or Simultaneous. For these dichotomous ways of processing information, the labels of other researchers are cited: Synonyms for 'sequential' are serial, successive, analytic, propositional, verbal, controlled, and time-ordered; contrasting synonyms for 'simultaneous' are synchronous or parallel, multiple, gestalt/holistic, appositional, imagery, automatic, and time-independent.

²⁹Similarly, when children's scores on Gordon's (1986) Cognitive Laterality Battery were factor-analyzed, the two serial tests showed negligible, and the least, differentiation between the 'verbal-sequential' and 'visuospatial' categorizations. These tests of sequencing abilities would seem, therefore, to assess something other than, or more than, left-hemispheric functions.

compared with scores on a test of arithmetic computation, and one point from the highest with scores on a test of reading comprehension. When hearing-impaired children were tested with the K-ABC, they "succeeded on tests that are heavily simultaneous, but had considerable difficulty on subtests demanding integration of sequential and simultaneous processing" (ibid., p. 145).

The Kaufmans recommend that children not be given the Photo Series subtest until the age of six (older than for the other nine Processing Scale subtests), by when they can have developed a concept of temporal relationships. Also having recognized difficulties young children have in sequencing pictures, Wechsler (1971) omitted the Picture Arrangement subtest in the WPPSI (Wechsler Preschool and Primary Scale of Intelligence).

Both the Performance and the Verbal Scales of the WAIS (Wechsler Adult Intelligence Scale) were included in the gamut of measures to predict the academic achievement of 16- and 17-year-old deaf students, who from preschool on had been educated in total communication programs. For those whose parents were hearing, Picture Arrangement was found to be one of the five strongest predictors of reading achievement and was the WAIS Performance subtest that correlated the highest with reading achievement (Moores and Sweet 1990). Out of 31 independent measures, only Picture Arrangement and the TSA (Test of Syntactic Abilities) were selected for the final equations to predict both reading and writing achievement. For the two groups of deaf adolescents in the study (those of hearing and those of deaf parents), the factors seen to be predictive of literacy were not hearing or fluency in speech or signs (whether based on English or ASL) but those that are most highly related to knowledge of English vocabulary and grammar.

In reference to these past studies, the methodology used in the thesis studies is reported next, concluding Part II.

* Insertion to page 32

The main variables explored were sequencing task scores, hearing status, and patterns of hand use during various tasks. Other factors analyzed were age, sex, birth order, name-writing ability, visual problems (e.g. strabismus), the categorical (right, left, or ambidextral) handedness of the children and others in their families, and the deaf children's aetiology of deafness and mode of communication. The sequencing task scores were also compared with re-test scores and with teachers' reports of the children's progress several years later at school. Case study material has been included to illustrate the performances of children whose scores and handedness patterns differ. From the specific information and relationships between the variables studied, it might be possible to identify factors that could be followed up in subsequent research.

Research Methodology

Objectives: The following were the six objectives of this research.

1. To determine if a sample of deaf children in comparison with hearing children would have difficulty in doing various kinds of sequencing tasks: what general abilities and disabilities might be specified, and how aetiology and method of communication might be associated with differences among the children.
2. To assess the children's handedness patterns when in contact with the test materials.
3. To discover progressions in, and any correspondences between, the children's sequencing abilities, their language, and their manual actions.
4. To investigate whether other factors (sex, birth order, familial handedness, and name-writing ability) might also reflect differences in the children's scores.
5. To provide evidence either to support or disprove the thesis that specialized and coordinated functions of the hands, and by implication of the cerebral hemispheres, contribute to success on these sequencing tasks -- success possibly related to ratings of later academic achievement.
6. To consider applications of the results to practical educational issues.

*

Tasks: In the Preliminary Study (reported in Chapter 2), various sequencing tasks that include picture sequences were administered to 20 deaf and hearing children. Three of the tasks (with alterations described in Chapter 3) were used in the Main Study when 60 other children were tested. Additional tasks were performed in a Handedness-Sidedness Inventory, an adjunct to the Main Study that was conducted to assess general laterality preferences (see Appendix H).

As the intent of the research was to learn about *how* as well as *how well* the children would do the sequencing tasks, the testing sessions were videotaped. From these recordings, it was possible to analyze the children's responses -- their manual actions and their verbal (spoken and signed) expressions, i.e. all that was communicated that could give clues to what and how the children were thinking.

Subjects: Four- and five-year-old nursery school children (10 deaf and 10 hearing) participated in the Preliminary Study. In the Main Study, the age range of the children (20 deaf and 40 hearing) was extended down to three years and (for the deaf children) up to seven-and-a-half years.

Criteria for the deaf children reflect the general school-age deaf population: The majority have hearing parents; the hearing loss of all but three of the 30 deaf children is in a severe to profound range; slightly more are boys; none have additional handicaps that exclude them from enrolment in regular classrooms; some are educated in oral programs, most in total communication programs.

As many left-handed and ambidextrous children as possible were included in order to investigate reported atypical cortical laterality patterns that might be associated with preferred hand use, precisely at an age when lateralities of hemispheres and handedness are still developing. With a broad spectrum of handedness, the influence of this variable on performance could be explored. Information provided by the parents further distinguished the children with familial and those with nonfamilial left-handedness histories.

Information about the children's educational backgrounds, birth order, ethnicity and bilingualism, and about the deaf children's hearing losses was obtained from the schools (on forms included in Appendix F). Additional information received from teachers rated the children's progress at school two or three years after they had participated in the studies (Chapter 8).

Risks: As this research was exploratory, the decision was made to err on the side of inclusion rather than exclusion, i.e. not to ignore possible causal or correlated factors prior to

investigation.³⁰ For the reader, as for the researcher, a consequence of this approach, of considering multiple variables (and believing that all aspects of a presentation are meaningful), is complexity -- and tedium from what may appear trivial.

By including some complete transcriptions and the minutiae of data in some analyses, I tried to balance disadvantages of selectivity with advantages of inclusivity: objectivity, validity, and replicability. With exceptions reported, and with those to whom a statistically significant result does not apply also described, there seemed to be a better chance to avoid myths and generalizations and to approach 'truth' (before there would be change, and the need for re-definition). In describing and quantifying the handedness ratios and patterns reported in this thesis (particularly in Chapters 4 to 6), I have tried to be comprehensive and yet to uncover the 'grundformen' -- the fundamental forms.

If the analyses of the children's expressions provide insight into the processes of how children think, perhaps later it will be said that "the very difficulty of the undertaking ensured its value" (Lurie 1984). Our awe and appreciation of children's attainment of knowledge may increase and contribute to a greater understanding. But the risks of all research remain: Two dangers are extrapolation and exaggeration.³¹ Morris (1989, p. 240) comments on a problem in (but presumably not exclusive to) parapsychology, the influence of expectations and biases on one's observations: "We are good at noticing patterns and pattern similarities, but not always able to tell whether we have detected a real or an imposed similarity." And always there is the possibility of errors in

³⁰In their description of various types of research, Phillips and Pugh (1987) indicate poignant disadvantages of an exploratory approach.

³¹A numerologist, Paulos (1988, p. 28), warns against the fancy of a pet theory, reminding us of 'the ubiquity of coincidence': "...it would be very unlikely for unlikely events not to occur."

the interpretations, in inferences of what might be causes and implications of factors that correlate: "...establishing the nature of the relations between actions and thoughts is no simple matter" (Wood 1988, p. 19).

An omission that I regret, mostly because it is misleading, is the lack of humour in much of the text. My curiosity about the children I taught and the children I tested was great, but less than the joy they gave me.³²

³²To end this first chapter with a footnote (a technique -- in addition to the headings, tables, and graphs -- meant to clarify obscurities but which in abundance may instead be an annoyance), I am adding a confession: To the 'jo' I first typed a 'b' instead of a 'y'. The reason will be understood especially by those who have worked with deaf children: Both 'joy' and 'job' are true!

CHAPTER 2

PRELIMINARY STUDY

*... a different drummer*¹

Henry David Thoreau

A purpose of the Preliminary Study was to determine if a sample of deaf children would tend to score lower than hearing children on a variety of sequencing tasks. Another purpose was to learn how the children would do the tasks: Their actions were of paramount interest; process as well as product was considered important.

SUBJECTS

Twenty children were tested in the Preliminary Study. Half are deaf children. Five of the hearing children and six of the deaf children are boys. The age range is two years, from 3:9 to 5:9 (mean = 4:8), the deaf children averaging one month older than the hearing children.

Educational backgrounds varied: from four hearing children who had had less than one-and-a-half years of half-day nursery school experience to two deaf children who had had peripatetic teachers from infancy, i.e. approximately four years of instruction. Previous instruction averaged one year more for the deaf children than for the hearing children (2.7 versus 1.8 years); by the medians, the difference is less (three months). The hearing children were attending nursery schools in Edinburgh, half at the Psychology Department nursery at the University and half at a nursery within a primary school.

¹The complete quotation, the conclusion of *Walden* (1854), is:

If a man does not keep pace with his companions, perhaps it is because he hears a different drummer. Let him step to the music which he hears, however measured or far away.

Five of the deaf children were in total communication programmes in Northern England -- three at a residential school for deaf children and two in the day class at a county school; the other five deaf children were in an oral programme, integrated in nursery schools or a play group in and near Edinburgh.

All the deaf children have hearing parents; one has a younger deaf sibling. None have additional handicaps. Hearing losses were reported to range from moderate to profound (55-110 dB in the unaided better ear). Of the children in the total communication classes, the median hearing loss is 100 dB, within the profound range; of the children in the oral classes, the median is 70 dB, at the high extreme of the moderate range. Aetiologies reported are genetic factors (three children), meningitis (one child), and unknown causes (six children). For all, the onset of deafness was prelingual: about 8 months of age for one, at birth for the others.

In birth order, 10 of the children were first-born, and one is an only child. All the children were living with both their natural parents. One hearing child is bilingual, and one deaf child is of an ethnic minority.

Regarding handedness, 15 children were reported to be right-handed, two left-handed, and three ambidextrous. Of the right-handed children, seven are girls, eight are boys; the left-handers are girls, the ambidextrous children are boys. Of the children who are not right-handed, one is deaf and four are hearing.² Ten of the right-handed children have a familial 'left factor': Relatives reported to be left-handed/ambidextrous are a parent (seven children); a sibling, an uncle, a parent and two half siblings (one child

²The four hearing left-handed/ambidextrous children actually represent about 9% of the total number of hearing children in the nurseries, similar to the 10% representation of the deaf children who qualified for inclusion in the study.

each).

Characteristics of the children, identified by pseudonyms, are shown in Table 2.1.

Table 2.1: PRELIMINARY STUDY CHILDREN

	School	Sex	Age	Birth order	Reported handedness	dB loss	Aetiology
<u>Hearing children</u>							
Scott	PDN	M	4:0	1/2	LR		
Zoe	PDN	F	4:1	1/2	L		
Shelagh	PDN	F	4:1	4/4	R		
Emma	PDN	F	4:4	1/2	R		
Gordon	PDN	M	5:0	2/2	R		
Douglas	PSN	M	4:11	1/2	R		
Judy	PSN	F	4:11	1/2	L		
Calum	PSN	M	5:0	1/2	LR		
Angus	PSN	M	5:2	2/4	R		
Fiona	PSN	F	5:2	2/2	R		
<u>Deaf children</u>							
Natasha	TC	F	3:9	4/5	R	100	Genetic
Keith	TC	M	4:9	1/2	R	100	Genetic
Patrick	TC	M	4:9	2/2	LR	85	UK
Mahmud	TC	M	5:3	2/2	R	85	UK
Jeremy	TC	M	5:4	6/7	R	100	UK
Kenneth	O	M	4:2	2/3	R	80	UK
Jean	O	F	4:4	2/2	R	55	Meningitis*
Simon	O	M	4:6	1/1	R	65	Genetic
Shona	O	F	4:8	1/2	R	70	UK
Lisa	O	F	5:9	1/2	R	110	UK

PDN = Psychology Department Nursery

PSN = Primary school nursery

TC = Total communication school/class

O = Oral class

*Onset of deafness about 8 months of age (all others at birth)

TASKS

To assess the children's abilities to sequence, diverse tasks were selected according to the following criteria.

- Scope: A sufficiently broad sample of ways to sequence for expression of individual skills, and for sustaining interest.
- Time: A range from 30 to 60 minutes for all the tasks to be completed, optimally in one session, optionally in two sessions.
- Materials: Portable testing materials that are specially made, foreign, or recently marketed to assure equal unfamiliarity.
- Language: Minimum language requirements so that the deaf children would not be penalized on the parts that are scored, yet providing an opportunity for spontaneous comments.

Standardized tests were excluded by these criteria, and by the objective of observing the children's actions in addition to

obtaining their scores when tested under similar conditions. Elements of seriation tasks that are subtests of standardized tests designed specifically to differentiate between verbal and non-verbal abilities, left and right hemispheric functioning, and their administration and scoring procedures, were, however, incorporated with adaptations appropriate to nursery-age hearing and deaf children.³

The six tasks chosen to meet the criteria are described below and are reproduced in Appendix A (in black-and-white, although the materials used are in colour); the score sheets (reduced in size) are in Appendix F. Modifications of the three tasks (Tasks 1, 3, and 4) that became the Main Study tasks (Tasks A-C) are noted in brackets, '[]'.

Task 1: Three-part picture sequences (a demonstration set plus three test sets [Task A, with five additional sets of two to five pictures per set]).

The cards are placed in a conventional left-to-right order illustrating first-to-last irreversible temporal sequences. For example, the demonstration set pictures are of a whole apple, an apple being eaten, and an apple core. Instructions to the children are to look at all the cards carefully, thinking of which would happen first, which next, and which last, and to place them on the board in that order to tell a story of what happens. Supplemental words and signs to describe the sequence of events in the sample and subsequent instructions are "first, second, and third", "first, then, and then finally", "the beginning, middle, and end", "before, after" (with the signs to the child's left and right, respectively) and "later-later" (with the sign repeated).

The cards of each set are presented in a pile, face down, in an incorrect order that is the same for all the children (e.g.

³Examples of tests referred to are the WPPSI and the WISC-R (Wechsler 1971, 1976) and Gordon's Cognitive Laterality Battery (Gordon 1986).

as 2-1-3 for the demonstration set). When the child has arranged the cards, he is asked to tell the story the pictures show. If in the first test set the child merely puts the turned-over cards down in the given order, possibly mistaking the "first, next, last" instructions, the order is corrected by the examiner, thus affirming that a change is permitted and necessary. If the preceding sets have been sequenced correctly, a probe is for the examiner to ask what might happen next, after the event in the third card, e.g. after the string is broken and the kite is stuck in the tree. The conclusion of each set is for the child to collect the cards in the first to last order and place them in the box, and finally to replace the lid [and put the rubber band around the box].

Scoring (six total points): One point is given for each pair of correctly sequenced pictures, with full credit for a complete reversal of the three [four or five] pictures (i.e. a 3-2-1 placement) if, when asked what happens, the child describes or points to the events in that same, right-to-left, order.

Task 2: Nine-part picture story (from Madeline's Rescue by Ludwig Bemelmans).

The child's ability to recollect the sequence of events in a nonverbal story is shown in the order the pictures, when disarranged, are selected and presented across the table to the examiner. This ordering is necessitated by the size of the pictures (each 6.5 inches wide by 8 inches high, except for the third double-frame picture), which does not allow placement of the nine pictures in a line along the board. It also was intended to be an alternative mode direction for children as yet unfamiliar with conventional left-to-right positionings and for deaf children, as this orientation corresponds more logically to temporal locations in sign languages, in which tense is marked spatially in reference to the body not in a horizontal left-right direction but with a backward movement to indicate the past and a forward movement

to indicate the future.

The child is told that the story is about a little girl and is asked to look at the pictures carefully and remember what happens, so that when the book is taken apart and the pictures are mixed up, he will be able to put them back together in the same story order, first to last -- from the beginning to the end.⁴ As the child 'reads the book', the examiner responds affirmatively to comments and intervenes only when necessary to ensure, by pointing, that the child's attention is drawn to significant details (e.g. the heroine in the first picture, the drowning in the third picture, the rescue in the sixth). The child is asked if he can remember the story or wants to read it again. [When the pictures are re-assembled, the final request is for the child to tell what the story is about.]

Scoring (nine total points): One point is given for each picture that is in the correct ordinal position and for each pair that is a) in the correct ordinal position but the order of the two pictures is reversed or b) in sequence but not in the correct ordinal position. In the following examples, each underscoring represents one point.

a) 1-2-5-9-3-7-6-4-8 (three points)

b) 1-2-3-7-6-4-5-8-9 (six points)

Task 3: Six-part size progressions of circus cutouts (a demonstration set plus two test sets [Task B]).

The cutouts are placed on the board in a linear sequence, from the smallest at the child's left to the largest at the right.

In the demonstration, the child is asked to find the littlest ball from the jumble and to put it on the board at the (pointed to) left. Further "littlest now" decisions and "next

⁴A masculine pronoun is used to refer to an unnamed child; a feminine pronoun refers to the examiner.

to" placements are prompted. Comparative measurements, continually to determine the smaller object, and one-directional placements are suggested in an attempt to prevent confusions of transitive operations (simultaneous two-directional 'bigger than - smaller than' judgments). The single direction is reinforced and the pattern of progressive enlargement is emphasized by the examiner [first when checking the order by stating "bigger, bigger ... and the biggest" while manually encircling the balls, then] by collecting the balls cumulatively onto the largest and flicking the graduated edges. Synonyms used are "little, small, wee, tiny, baby; short" and "big, large; tall, long". (For speechreading contrast, "little" and "big" were preferred to "small" and "large".)

With the clowns and the dogs in the test sets, when the child has affirmed he has finished and that the seriation is 'right', the placements are recorded, and the child is asked to collect the objects from the littlest to the biggest and replace them in the envelope.

Scoring (12 total points): One point is deducted from the set total if the set is correct except for the position of one object. Otherwise, one point is given for each shape in the correct ordinal position, with no deduction for a total reversal.

Task 4: Three-part shape pattern continuations (a demonstration set plus two test sets [Task C, with substitutions in set 2 and the addition of a third set]).

A pattern of three different shapes is repeated three times in a horizontal array. The shapes, made of felt, differ in colour, size, and shape. In only the first test set is one attribute constant: All the shapes are large but vary in colour and shape (a large blue square followed by a large red rectangle followed by a large yellow triangle). A trick shape, like one other but for its size, is included in the second test set.

The three stimulus shapes are placed by the examiner and named by the child. The words/signs he uses (whether colour, size, or shape names, or any other descriptors) are those the examiner repeats for the pattern to be imprinted verbally as well as visually. The child is instructed to repeat the pattern with his shapes, placing them in that same order "again and again and again" in a line.

In the demonstration, the groups of three are emphasized by being separated by a gap; by being blocked together with a gesture when checked, showing their same internal pattern; and by being collected (from the child's left to right) into piles of three, with interim pauses [and in synchrony with the child's recitation of his names for the shapes].

Scoring (six total points): One point is given for each correct group of three, with no penalty for having the trick shape incorporated if no group is disrupted.

Task 5: Three-part clapping pattern imitations (a demonstration set plus three test sets).

This task involves visual, kinaesthetic, and auditory perceptions, cognitive coding with short-term memory of sequences, and manual control. With the table moved away so movements are unobstructed, and with the child's hands clasped or sat on, a pattern of three claps is demonstrated, then repeated by the child. In the practice and first test pattern, only timing varies (e.g. clap, pause, clap, clap); in the other two test sets, only intensity varies (e.g. quiet, loud, quiet).

To introduce the task, the child and examiner clap together, altering speed and intensity. Next, the child is instructed to wait while he watches the examiner clap three times, then to repeat the same three claps. In the test patterns, a second attempt is allowed and, if better, is the one scored. At the conclusion, the child is applauded for his efforts.

Scoring (six total points): One point is given for the correct

count and one for the correct rhythm in each of the three test sets.

Task 6: Three-part movement imitations with Simon Says cards (a demonstration set plus two test sets and one last set with the child role-playing the examiner).

This is a nonverbal visual-motor sequential memory task. It is presented as a game, with chance and turn-taking elements. From the pool of 11 cards face-down on the adjacent board, the child selects three cards. Without peeking, he places them in the slot of a wooden holder toward the examiner. She says she will do the three things she sees in the pictures, "first, next, and last", touching the cards in the child's left-to-right direction. The child is told to try to remember what the examiner does in that (tapped) order and then to do the same.

In silence, the examiner models the three actions, repeating a test series once if the child initiates no action. The child's actions are verified (or eventually prompted, with no score awarded) by having the cards turned over. With the remaining two cards plus one other of the child's choice, the roles are reversed: The child models (and prompts or corrects) the actions for the examiner.

Scoring (six total points): One point is given for each correct imitation, with one point deducted for an order error in a set.

General procedures. The six tasks were presented in a fixed order, from Task 1 to Task 6, to all the children. The sets within the tasks and the materials to be sequenced were in the same order for each child. A constant and optimal condition with equal order effects (such as fatigue, anxiety, monotony/novelty, cumulative task practice) was thus ensured, and seating rearrangements were simplified. The tasks administered first were those considered to have the greatest cognitive demands and to show the greatest differentiation in the skills of hearing and deaf children.

If a child were to opt not to complete the test, the results of these target tasks would not be jeopardized.⁵ A left-to-right orientation could be established in the first-to-last ordering of the materials in Task 1. The two tasks that require unobstructed movements and allow for a release of tension avoid other activity-state (and table) changes when presented together. With Task 6 presented last, the role reversal provides a positive conclusion to the testing session.

The children were tested individually in rooms adjacent to their classrooms; they were familiar with the researcher testing them, having had at least one previous visit. (The one exception was a deaf child tested at her home and afterwards observed at her play group.) The tasks were presented by the researcher to each child in his usual mode of communication (oral or spoken and signed). The peripatetic teachers of the oral deaf children were present to assist with interpretations. At the start of the testing session, the child was asked if he would write his name on the score sheet by himself or with assistance, or if he would spell or say his name to assist the examiner in writing it. At the conclusion of the sessions, a brief part of the videotape was played back for the child to see himself 'on TV'.

All the sessions were videotaped. No time limits were set, but Tasks 1, 3, and 4 were timed, from when the child first made contact with the materials until he looked up after the final placement.⁶ Subsequent changes were also recorded, with

⁵Two children did not complete the last two tasks. The one who is hearing (Shelagh) and the other who is deaf (Jean) had the lowest scores of all the children on the four tasks they did complete (8.5% and 10.5%, respectively). When Shelagh was re-tested and completed all the tasks, her total score was again the lowest of the hearing children.

⁶The total testing time averaged 42 minutes (from 29 to 58 minutes) -- 35 minutes for the hearing children, 49 minutes for the deaf children.

the final arrangement scored.⁷ The raw score on each task was converted to a percentage score, with the mean calculated and reported as the child's 'total per cent score'. From the videotapes, transcripts were made and handedness counts were obtained.

To examine any possible effects caused by the fixed order of the tasks, five children (25% of the sample) were re-tested five months later with the order of the tasks randomized. Approximately one year later, four of the other hearing children and four of the deaf children were re-tested on the six tasks of the Preliminary Study, with the Main Study additions, and completed the Handedness-Sidedness Inventory (Appendix H).

HANDEDNESS

Measures of the children's handedness were a) the categorical hand preference of the children as reported by the parents (see Appendix F) and b) the handedness ratios of the times each hand was used when contacting the materials during the testing.

To quantify how the children were using their hands while doing the tasks, counts were taken from the video recordings using an event recorder computer program. Only manual contacts with the materials were counted, as Hampson and Kimura (1984) have found asymmetrical associations between kinds of tasks and spontaneous hand movements "only for movements playing a functional role in task performance" (p.102). Other hand movements, including the children's signs and gestures, were, instead, noted in the transcriptions made

⁷Although scores could have been derived from the videotapes, the responses were recorded in the children's presence in recognition of the Zlotnick Principle: *The written word is important* (Mindy Zlotnick, personal communication). (The impact of the Zlotnick Principle had been realized by the researcher when a severely multihandicapped deaf student pointed imperatively to the clip board and nodded, satisfied, when notes were written down.) The timer also served as an authenticity cue.

from the video recordings.

Two tasks were considered appropriate for handedness counts. They were administered in the middle of the test battery and require the greatest breadth of movements in placing and removing the objects along the board -- of six objects in Task 3 (Size Progressions) and of nine objects in Task 4 (Pattern Continuations). Also, Task 3 provides the largest range of scores (with 12 points the maximum possible, versus nine for Tasks 2 and 6, and six for the others). In neither task is there a memory requirement, yet each represents a cognitive aspect the test differentiates: a logical progression by size in Task 3, an arbitrary progression by shape in Task 4.

As different methods of handling the materials could be associated with different degrees of deliberation/attention, with different kinds of thought involved within as well as between the tasks, movements were counted separately for each task and for contacts defined as Placements (P) and Collections (C). Simultaneous left-hand (L) and right-hand (R) contacts with the materials on the board were tallied together. Re-runs were done until certainty of accuracy was attained. Inter-rater reliability counts were made on the P and C contacts of eight children (40% of the sample, with two children from each hearing nursery and two each from the total communication and oral classes). From the counts, Task Handedness Ratios (THRs) were calculated using the formula $(R-L)/(R+L)$. Negative ratios indicate a greater proportion of left-hand contacts, positive ratios a greater proportion of right-hand contacts: Exclusive use of the left hand yields a THR of -1; of the right hand, +1.

TEST RESULTS

Findings of the Preliminary Study indicate that task success is significantly related to hearing status, hand use, and birth order: On half the tasks, the hearing children have significantly higher scores than the deaf children. Higher scores of those with greater left-hand use contrast significantly to the lower scores of those with greater right-hand use; also, higher scores are associated with a familial

'left factor' and lower scores with no familial 'left factor'. First-born children have higher total scores than those who have older siblings.

Three of the sequencing tasks differentiate the skills of these hearing and deaf children, the hearing children having significantly higher scores. The greatest difference in the scores of the hearing and the deaf children is on Task 1, the picture-card sequences (M-W $U=19$, $p<.01$).^{8 9} The other tasks on which scores of the hearing children are significantly higher are Task 3, the size progressions, and Task 4, the shape pattern continuations (M-W $U=27$ and 25 , respectively, both at $p<.05$).

The total scores of 80% of the hearing children are above the mean, in contrast to 70% of the deaf children whose scores are below the mean ($p<.05$). On no task do more deaf than hearing children score above the mean, or median. The task that least differentiates the scores of the children is Task 6, the action imitations: Exactly half of the hearing children and the deaf children scored above and below the mean, and median.

The three tasks on which the scores of the hearing and the deaf children differ significantly (Tasks 1, 3, and 4) are the three tasks that correlate most significantly with the total scores and with the other tasks, as shown in Table 2.2. The two tasks from which the handedness ratios were obtained, Tasks 3 and 4, have the highest intertask correlation and together the highest correlation with the total scores. (Task 2 correlates significantly only with Task 1, the other narrative sequencing task, and Task 6 only with Task 5, the

⁸As the data do not form a normal distribution curve, nonparametric statistical tests were required; z-scores and multivariate analyses were precluded. Correlations reported, with their significance levels, are the Spearman correlation coefficients (r_s). To measure differences between bivariate groups, the Mann-Whitney (M-W) Test was used; for differences between above- and below-mean groups of the few children in the Preliminary Study, the probability values and percentages cited are from the Fisher's Exact Probability Test.

⁹The children's individual scores and the collective mean and median scores are included with handedness data in Table 2.3.

other gross motor task.)

Table 2.2: CORRELATION COEFFICIENTS OF SCORES

	Task 2	Task 3	Task 4	Task 5	Task 6	: Tasks 3-4	Total Tasks 1-6
Task 1	0.40*	0.65**	0.57**	0.17	0.25	: 0.66**	0.74***
Task 2		0.33	0.27	0.22	0.01	: 0.35	0.56**
Task 3			0.70***	0.23	0.28	: 0.89***	0.81***
Task 4				0.42*	0.34	: 0.93***	0.78***
Task 5					0.45*	: 0.34	0.62**
Task 6							0.44*
Tasks 3-4							0.86***

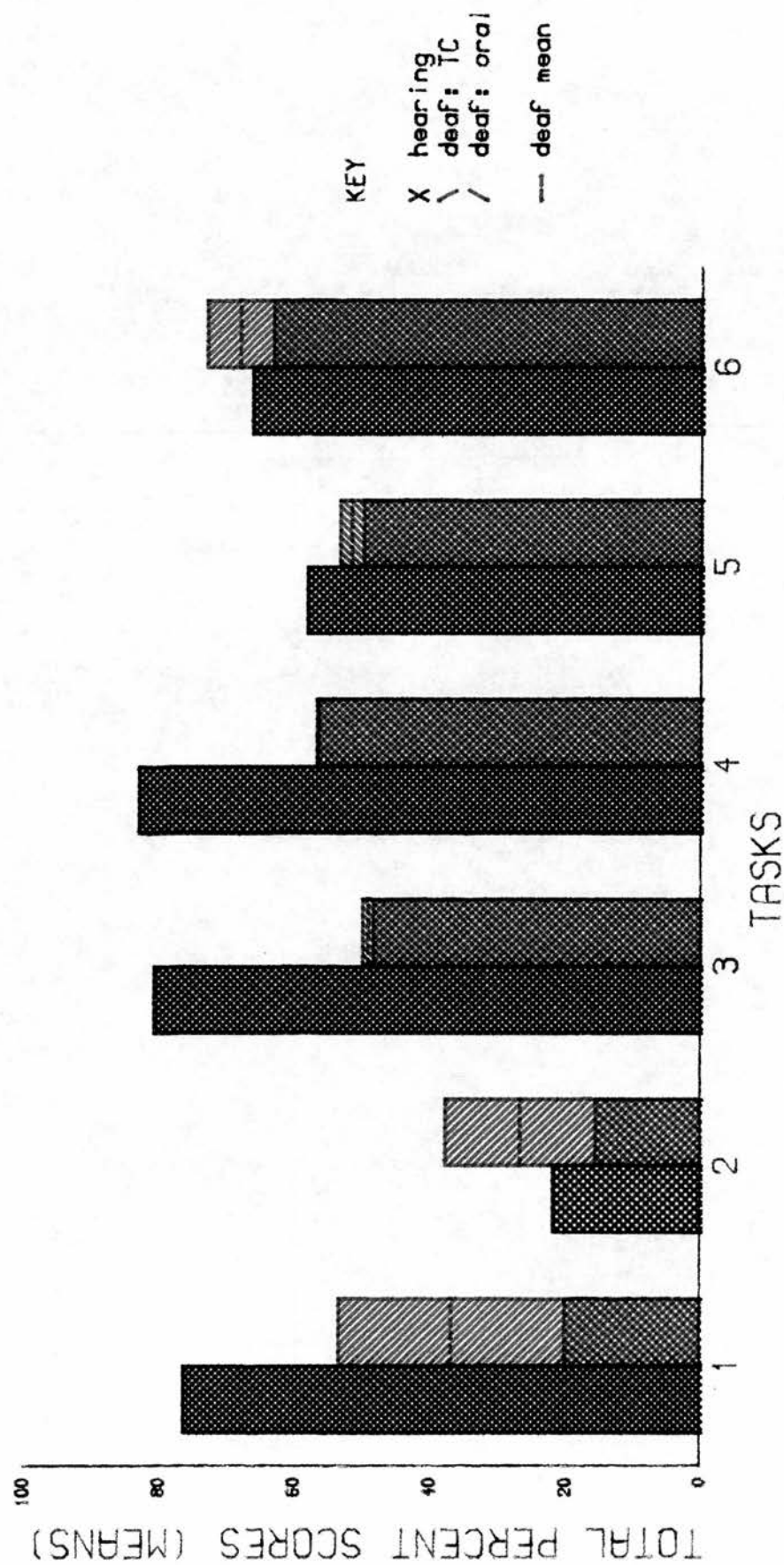
* $p < .05$
 ** $p < .01$
 *** $p < .001$

In Figure 2.1, the mean scores on each of the six tasks are compared, with the deaf children's scores separate for those in total communication (TC) classes and those in oral classes. Differences by mode of communication are significant between the hearing children and only the oral deaf children, whose total scores and scores on Tasks 1 and 3 are much lower (respectively, M-W $U=10$, $p < .05$; M-W $U=3.5$, $p < .005$; M-W $U=10.5$, $p < .05$).

The single task on which the scores of the two groups of deaf children differ significantly is Task 2 (M-W $U=4$, $p < .05$), the total communication children scoring slightly more than two times higher.¹⁰ The two highest scorers of all the children on Task 2 are both deaf: The child who scored the highest (and has the highest total score) is in a total communication class; the child who scored the second highest is in an oral class.

¹⁰Although on Task 1 the total communication children score approximately three times higher than the oral children, this difference is not statistically significant because of the high variance in the scores of the total communication children on this task.

Figure 2.1: SCORES/TASKS



Discussion. The supposition that sequencing tasks are more difficult for deaf than for hearing children is supported by the results of this test: The hearing children achieved significantly higher scores. This general result must not obscure two facts -- that on half the tasks the deaf children as a group did as well as the hearing children and that a few deaf children excelled, one having the highest test score of all the children.¹¹

...it should not be concluded of any young hearing impaired student that he or she will never achieve beyond a certain level. (Allen 1986, p. 205)

The greater disparity in the scores of the hearing and the oral deaf children conforms to results of most other studies, which document the comparative superior achievement of deaf children who communicate using sign language -- even though deaf children in total communication programmes generally have, and those in this study do have, more severe hearing losses than deaf children in oral programmes.

The three tasks on which the deaf children's scores are significantly inferior to the scores of the hearing children (Tasks 1, 3, and 4) require an ability to visually relate but not recall the elements in the sequences. In contrast, the three tasks on which the deaf children's scores are similar to (marginally above or below) the scores of the hearing children are the three tasks that require visual memory: to recall the sequence of the story events in Task 2 and the pattern of claps and actions in Tasks 5 and 6. That the deaf children were able to detect, retain, and repeat these visual sequences may reflect skills developed because of their dependence on visual stimuli and an imitative facility. That they do less

¹¹The deafness of the top scorer and the other highest scorer on Task 2 is known to have been caused by genetic factors. Among the deaf children, they ranked first and fifth. The girl whose aetiology is also genetic ranked sixth; the child who had had meningitis ranked tenth, the lowest. The cause of deafness is unknown for the other six children, with in-between ranks. (See Chapter 3 for a discussion of aetiologies, also footnote 18 of this chapter.)



well on the tasks that require detection of a temporal or spatial order could be associated with different thought processes consequent on their hearing and experiential deficits.

While in Task 2, as in Task 1, pictures are arranged in sequence, differences between them that relate to the discrepancy in the scores (the similar mean and median scores on Task 2, but the significantly lower collective scores for the deaf children on Task 1) include a) the different presentations of the pictures, across the table in Task 2, along the board in Task 1, and b) the memory factor. The series is longer in Task 2 (of nine versus three pictures), but is according to a prescribed narrative order that is retained, not a logical order that must be deduced.

Other Correlations. Neither age nor sex relates significantly to the total scores. Although the scores on each task correlate positively with age, the correlation is significant only on Task 6 ($r_s=0.42$, $p<.05$) and borderline on Task 1 ($r_s=0.38$, $p=.05$). There is a significant sex differentiation on only one task: The boys' higher total scores and scores on Tasks 1-3 reach a level of significance on Task 2 (M-W $U=21$, $p<.05$). Two other factors, however, do relate significantly to the children's total test scores.

Test scores and birth order. First-born children have higher scores on all six tasks than the children who have at least one elder sibling. Their total scores and scores on Tasks 4 and 5 are significantly higher (respectively, M-W $U=19$, $p<.02$; M-W $U=20$, $p<.05$; and M-W $U=14$, $p<.01$). For example, of the six children (30% of the total sample) whose total scores are the lowest, none are first-borns; of the other children, including the top three scorers, 71% are first-borns.

Test scores and handedness. Data of the children's handedness

and scores are presented in Table 2.3.¹² The children are listed in the order of highest to lowest total score (the two with a tied score, from the younger to the older).

Table 2.3: TASK PER CENT SCORES AND HANDEDNESS RATIOS

	Sequencing Task Scores							Task Handedness Ratios		
	T1	T2	T3	T4	T5	T6	Total	T3	T4	THR
Keith	100	89	100	83	100	67	89.8	-.282	.407	.063
Calum*	100	33	92	100	100	83	84.7	-.539	-.492	-.516
Douglas*	67	67	100	100	83	67	80.7	.137	-.215	-.039
Fiona*	100	0	100	100	67	100	77.8	.120	-.486	-.183
Zoe*	83	33	100	100	83	67	77.7	-.048	-.216	-.132
Jeremy*	83	67	100	100	17	83	75.0	.250	.391	.321
Emma*	83	33	67	100	83	83	74.8	.149	-.033	.058
Shona*	17	0	92	100	100	100	68.2	-.543	-.277	-.410
Scott*	100	22	100	100	0	67	64.8	-.419	-.153	-.286
Gordon*	83	0	100	50	67	83	63.8	.139	.565	.352
Angus*	100	33	67	83	17	83	63.8	-.464	-.120	-.292
Lisa*	33	0	25	67	100	100	54.2	.786	.747	.767
Simon*	17	78	50	33	67	67	52.0	-.309	.767	.229
Judy*	33	0	67	100	67	33	50.0	-.211	-.082	-.147
Natasha*	0	11	17	67	83	83	43.5	-.125	.913	.394
Mahmud	67	11	0	33	50	50	35.2	-.040	.698	.329
Kenneth	17	0	75	67	0	50	34.8	.200	.280	.240
Patrick*	17	11	25	0	0	83	22.7	.132	.167	.150
Shelagh	17	0	17	0	17	0	8.5	.385	.373	.379
Jean	17	0	8	17	0	0	7.0	.355	.254	.305
means	57	24	65	70	55	67	56.5	-.016	.174	.079
medians	67	11	71	83	67	75	63.8	.040	.210	.106

Deaf children

Left-handed/ambidextrous children

*'Left factor' present

The children's scores are not differentiated by their categorical handedness: Three left-handed/ambidextrous children scored above the mean, two below. However, compared with the few children who have no familial 'left factor' reported, the children with a left factor have higher scores on every task (significantly higher scores on Tasks 4 and 6, with M-W $U=12.5$, $p<.05$, and M-W $U=5$, $p<.005$, respectively). One of the five children with no left factor was the top scorer; the other four scored in the bottom 25%.

Also important is the significant correlation of the children's handedness ratios with their total scores ($r_s=-0.55$, $p<.01$). As shown in Table 2.4, the more leftward (negative) ratios are associated with higher scores on every task (with

¹²To test the accuracy of the researcher's counts, the Tasks 3 and 4 Placement and Collection contacts of four hearing and four deaf children were counted independently by another researcher who is skilled in analysing videotapes. The handedness ratios from both their counts correlate highly ($r_s=0.93$, $p<.001$).

the single discrepancy having the lowest coefficient). The three tasks on which a level of significance is reached are Tasks 1, 3, and 4, i.e. *the three tasks that also show significant hearing-deaf score differences*, including the two tasks from which the handedness ratios were obtained (Tasks 3 and 4). The strongest correlations are with the handedness ratios on Task 4, the shape pattern sequences, the task requiring (and allowing) the greatest breadth of movement.

Table 2.4: CORRELATIONS OF HANDEDNESS RATIOS WITH SCORES

	<u>Handedness Ratios</u>		
	Task 3	Task 4	Tasks 3-4 (THR)
<u>Scores</u>			
Task 1	-0.30	-0.45*	-0.52**
Task 2	-0.34	0.01	-0.23
Task 3	-0.24	-0.48**	-0.48**
Task 4	-0.38*	-0.66***	-0.68***
Task 5	-0.29	-0.09	-0.16
Task 6	-0.18	-0.17	-0.18
Tasks 3-4	-0.34	-0.62***	-0.61***
Tasks 1-6 (Total)	-0.38*	-0.48**	-0.55**

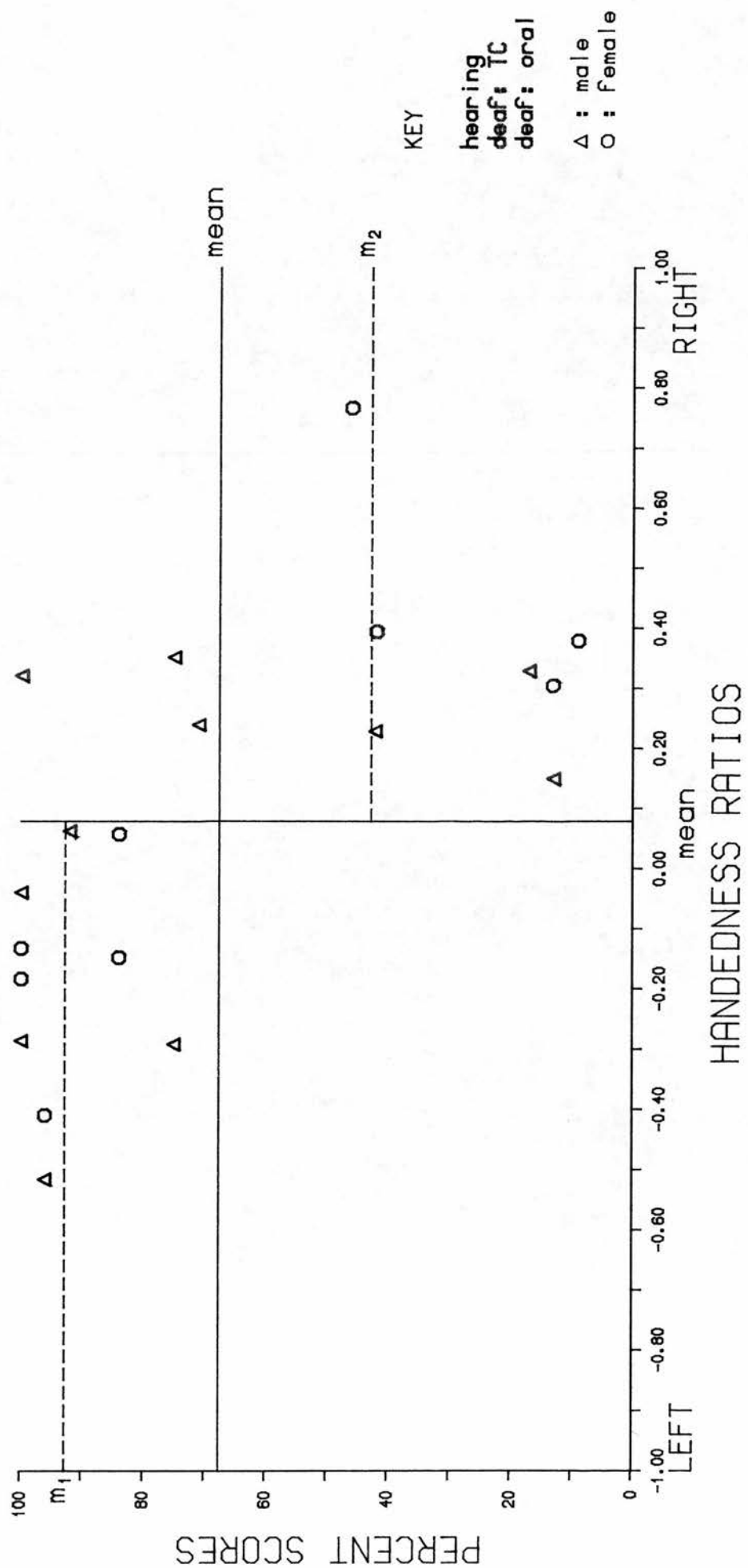
* $p < .05$

** $p < .02$

*** $p < .005$

Tasks 3 and 4. The children's mean ratios and scores on Tasks 3 and 4 are plotted in Figure 2.2. The mean score of the children whose ratios are left of the mean (m_1) is 92.7%, more than two times higher than the mean score of the children whose ratios are right of the mean (m_2), at 42.8%. Whereas seven of the ten children who have *right-of-mean* handedness ratios scored below the two-task mean, all the children who have *left-of-mean* ratios have above-mean combined scores (two-tailed $p < .01$).

Figure 2.2: TASKS 3 & 4



When the handedness ratios are correlated with the scores on the corresponding two tasks (Tasks 3 and 4), the pattern is the same as with the total scores -- of superior scores with leftward ratios, but the correlation is more significant ($r_s = -0.61$, $p < .005$; Fisher's two-tailed $p < .005$), and the correlation of the scores on the two tasks with hearing status is significant ($r_s = 0.43$, $p < .05$).¹³

Hearing status. The distributions of the hearing and the deaf children by mean handedness ratios and total scores are shown in Table 2.5.

Table 2.5: RATIO AND SCORE DISTRIBUTIONS OF THE HEARING AND DEAF CHILDREN

	Left-of-mean ratios (10 children)		Right-of-mean ratios (10 children)	
	Hearing	Deaf	Hearing	Deaf
Below-mean total scores (9 children)	1	0	1	7
Above-mean total scores (11 children)	7	2	1	1

The deaf children not only have significantly lower scores than the hearing children; they also have significantly more rightward handedness ratios (M-W $U=23$, $p < .05$). There is a difference of .320 in the mean handedness ratios of the hearing children (at $-.081$) and the deaf children (at $.239$), a difference of .411 in their median ratios (at $-.139$ and $.272$, respectively). With the left-handed/ambidextrous children excluded, to remove the bias of the greater proportion of categorically left-handed/ambidextrous hearing children, the mean difference between their ratios is .203 (.295 by the medians). While the one ambidextrous deaf

¹³The correlation of the two-task and the six-task mean scores is highly significant ($r_s = 0.86$, $p < .001$): Above- and below-mean distributions are identical for all but two children, whose Tasks 3 and 4 scores are above the mean but whose total scores are below the mean. (The effect of these two is nulled: One is a hearing girl who is left-handed and has a left-of-mean THR; the other is a deaf boy who is right-handed and has a right-of-mean THR.) Also, results are the same if median rather than mean total scores and THRs are used. With the Tasks 3 and 4 median scores and THRs, the significance is also high (Fisher's two-tailed $p < .002$): 90% of the children with leftward ratios have high scores and 90% of the children with rightward ratios have low scores.

child's THR is right of the total mean (and median), the THRS of both ambidextrous (and both left-handed) hearing children are left of the mean (and median). The rightward bias of the deaf children is seen also among the right-handers: Two of the right-handed hearing children (33%) but seven of the right-handed deaf children (78%) have right-of-mean handedness ratios. The significant three-part association of deafness, right-hand use, and low scores would seem to warrant further investigation.

RE-TEST RESULTS

A. *Re-test With the Order of the Tasks Randomized.* To test if there were an effect of the fixed order of presentation, the order of the tasks was randomized when the five hearing children from the Departmental nursery were re-tested five months later. In Table 2.6, the children's test scores with the fixed order of presentation are compared to their re-test scores with the order random. (The children are listed from the highest to the lowest mean score of the test and re-test totals.)

Table 2.6: TEST AND RE-TEST SCORES REGARDING PRESENTATION ORDER

	Task 1		Task 2		Task 3		Task 4		Task 5		Task 6		Total	
	T	RT	T	RT	T	RT	T	RT	T	RT	T	RT	T	RT
Zoe	83	100	33	67	100	83	100	100	83	83	67	50	77.7	80.5
Scott	100	100	22	44	100	100	100	100	0	67	67	83	64.8	82.3
Emma	83	83	33	56	67	92	100	100	83	33	83	17	74.8	63.5
Gordon	83	100	0	33	100	100	50	17	67	67	83	83	63.8	66.7
Shelagh	17	83	0	33	17	50	0	0	17	17	0	33	8.5	36.0
mean	73	93	18	47	77	85	70	63	50	53	60	53	57.9	65.8
median	83	100	22	44	100	92	100	100	67	67	67	50	64.8	66.7

T: Test score (%)

RT: Re-test score (%)

Left-handed/ambidextrous children

There is no significant difference in the ranks of the children's test and re-test total scores or their scores on five of the tasks (Wilcoxon two-tailed $p > .05$ for each).¹⁴ The

¹⁴The total scores of the children improved by an average of eight percentage points, with a range from 2.8 to 27.5, for the four children with higher re-test scores, a decrease of 11 points for the other child.

task that is the exception, on which the children's re-test scores are significantly higher ($W p < .05$), is Task 2, the task with the lowest scores, no ceiling effect, and thus the greatest possibility for improvement.¹⁵ The other task on which all the children's re-test scores were the same as before or higher is Task 1, the other picture sequencing task. On Tasks 3-5 there were fluctuations; on Task 6 only there is a consistent mean and median re-test score decrease.

The correlation of the children's test with re-test mean scores on the six tasks is highly significant ($r_s = 0.93$, $p < .005$); the correlation coefficients of the individual children average 0.65, in a range from 0.21 to 0.94. The three tasks on which the children's mean and median scores continue to be the highest are Tasks 1, 3, and 4, with their lowest scores again on Tasks 2, 5, and 6.

These re-test results confirm that the fixed order of the tasks did not distort the scores. Task difficulty rather than the fixed or random presentation order would seem to have determined the children's success.

B. Re-test One Year Later. At the time the Main Study children were being tested, eight of the Preliminary Study children were re-tested. The four hearing children are from the local nursery school. One of the deaf children is also from that nursery, tutored by a peripatetic teacher in the oral programme; the other three deaf children are the three from the residential school in England, in a total communication programme. When these children were first tested, their average age was 4:9 (the range from 3:9 to 5:3); when re-tested, their average age was 5:8 (from 4:11 to 6:0). In comparison with all 20 children, the proportion is higher among the eight children for those who are first-born (63% versus 50%) and for those who have a familial 'left factor'

¹⁵Similarly for individual scores, it is the overall score of only the lowest scorer that increased significantly.

(88% -- for all but one child -- versus 75%).

Scores. The children in this sample were re-tested on the six Preliminary Study tasks with the Main Study extensions -- five additional sets in Task 1 and a third set in Task 4. Their test scores are compared to their re-test scores on the original test items one year later (Table 2.7).

Table 2.7: TEST AND RE-TEST SCORES ONE YEAR LATER

	Task 1		Task 2		Task 3		Task 4		Task 5		Task 6		Total	
	T	RT	T	RT	T	RT	T	RT	T	RT	T	RT	T	RT
Keith	100	100	89	100	100	100	83	100	100	100	67	83	89.8	97.2
Calum	100	67	33	89	92	100	100	100	100	100	83	83	84.7	89.8
Fiona	100	100	0	89	100	100	100	50	67	100	100	67	77.8	84.3
Douglas	67	100	67	11	100	100	100	100	83	83	67	83	80.7	79.5
Simon	17	100	78	100	50	100	33	100	67	100	67	83	52.0	97.2
Judy	33	100	0	78	67	100	100	100	67	67	33	17	50.0	77.0
Natasha	0	67	11	11	17	75	67	100	83	67	83	83	43.5	67.2
Patrick	17	33	11	56	25	75	0	100	0	100	83	67	22.7	71.8
mean	54	83	36	67	69	94	73	94	71	90	73	71	62.7	83.0
median	50	100	22	84	80	100	92	100	75	100	75	83	64.9	81.9
D mean	34	75	47	67	48	88	46	100	63	92	75	79	52.0	83.4
H mean	75	92	25	67	90	100	100	88	79	88	71	63	73.3	82.7

T: Test score (%)

RT: Re-test score (%)

Deaf (D) children; hearing (H) children; left-handed/ambidextrous children

The test and re-test total scores of the eight children correlate significantly ($r_s=0.77$, $p<.02$). The re-test total scores of seven children improved (by 5.1 to 49.1 percentage points, the one decrease changing the least, by 1.2 points), altogether averaging 20 percentage points higher than the first test scores.¹⁶ A greater ceiling effect is evident in the number of perfect scores, which doubled to six on Task 3 and increased from four to seven on Task 4 -- one a 100% improvement. While the range of the total scores decreased, from 67 to 30 percentage points, the range of the combined scores on Tasks 3 and 4 (the THR tasks) narrowed still more,

¹⁶The additional Main Study sets only increased the children's scores: on Task 1 from a mean of 92% to 97% for the hearing children, from 75% to 82% for the deaf children. On Task 4, all the children had perfect scores on the extra set; the one child's only errors were on the re-test set 2. What this probably means is that if a child can do the tasks, this is shown in even a few sets, possibly even in the demonstration set. Such an all-or-nothing sequencing ability has been reported by teachers, who disclaim credit for -- and confess despair in -- teaching children this skill.

from 88 to 25 percentage points.

With the extra nine to 14 months between the test and re-test times, the eight children's total scores, and scores on Task 3, increased significantly (Wilcoxon two-tailed $p < .02$, $< .05$ on Task 3). The greatest improvement was again on Task 2, the task on which the scores of all the groups of children when tested and when re-tested are consistently the lowest, and the task on which the hearing children's scores had been conspicuously lower than the deaf children's scores.¹⁷ On Task 6 again the mean scores did not improve.

There was a significant hearing status difference on only the first Task 4 scores (M-W $U=0$, $p < .01$): All four hearing children had had perfect scores while the highest score for the deaf children had been 83%. The other two tasks on which hearing status most differentiates the first scores of the eight children are Tasks 1 and 3 (M-W $U=3$ for these two tasks, versus a U of 7 and 8, respectively, on Tasks 5 and 6). Because the greatest difference between the deaf and the hearing children is shown on the same three tasks for these eight children as for all 20 children, and the higher scores of the deaf children in this sample also are on Tasks 2 and 6, these re-test children can be considered representative of all the Preliminary Study children.

Tasks 1, 3, and 4, the three tasks on which the deaf children's scores on the first testing are much lower than the hearing children's scores, have a particular correspondence: On each of these tasks, the deaf children's re-test scores differ by less than one per cent from the hearing children's first test scores. Along with the merest, .007, difference in the deaf and hearing children's re-test total scores (M-W $U=8$, $p=1.000$), this result suggests a one-year retardation in the

¹⁷As the one deaf child in an oral programme who was re-tested had had a high score on this task even when first tested, the significant discrepancy between the Task 2 scores of all the oral and total communication deaf children could not be investigated further.

deaf children's abilities on these specific tasks, i.e. a transitory inferiority, not an unmitigated disability.

Individual differences are important to note. The lowest as well as the highest scorers both years are deaf children. The two children who scored the highest on the re-test are deaf boys.¹⁸ They both had perfect re-test scores on all but one of the six tasks. (The sole error of each was forgetting a final Simon Says position in Task 6.)

Handedness ratios one year later. The earlier handedness ratios of the eight children, as well as their scores, are compatible with those of the total group of 20 children.¹⁹ The difference between the mean THRs of the two groups is $<.1$ (with the mean $-.006$ for the eight children and $.079$ for the 20 children). The handedness ratios of this group of eight children when first tested also correlate significantly with their scores on Tasks 1, 3, and 4 (and Tasks 3 and 4 combined, although not with their total scores), each with a still higher correlation coefficient ($r_s = -0.66$, $p < .05$, on Task 3 to -0.84 , $p < .01$, on Task 4, corresponding to $r_s = -0.48$, $p < .02$, and -0.68 , $p < .002$, for the 20 children). Their earlier handedness ratios also were differentiated by hearing status: The THRs of the four deaf children were significantly more rightward than the ratios of the four hearing children (M-W $U=0$, $p < .05$).

One year later, not only were the scores of the hearing and the deaf children similar, but also their handedness ratios were more similar. The deaf children's THRs are still more rightward, but not significantly (M-W $U=5$, $p < .5$).

¹⁸They are Keith and Simon, the two whose scores on Task 2, the storybook picture recollections, were and continued to be the highest of all the children. The aetiology of their, and Natasha's, deafness is genetic.

¹⁹On the chance that the researcher's method of counting had changed between the first test calculations and those of the re-test, the contacts during the first testing were re-counted one year later. The correlation of the count and re-count handedness ratios is the highest possible ($r_s = 1.00$, $p < .001$): The consistency affirms the reliability of the counts.

Figure 2.3a
TEST AND RE-TEST SCORES

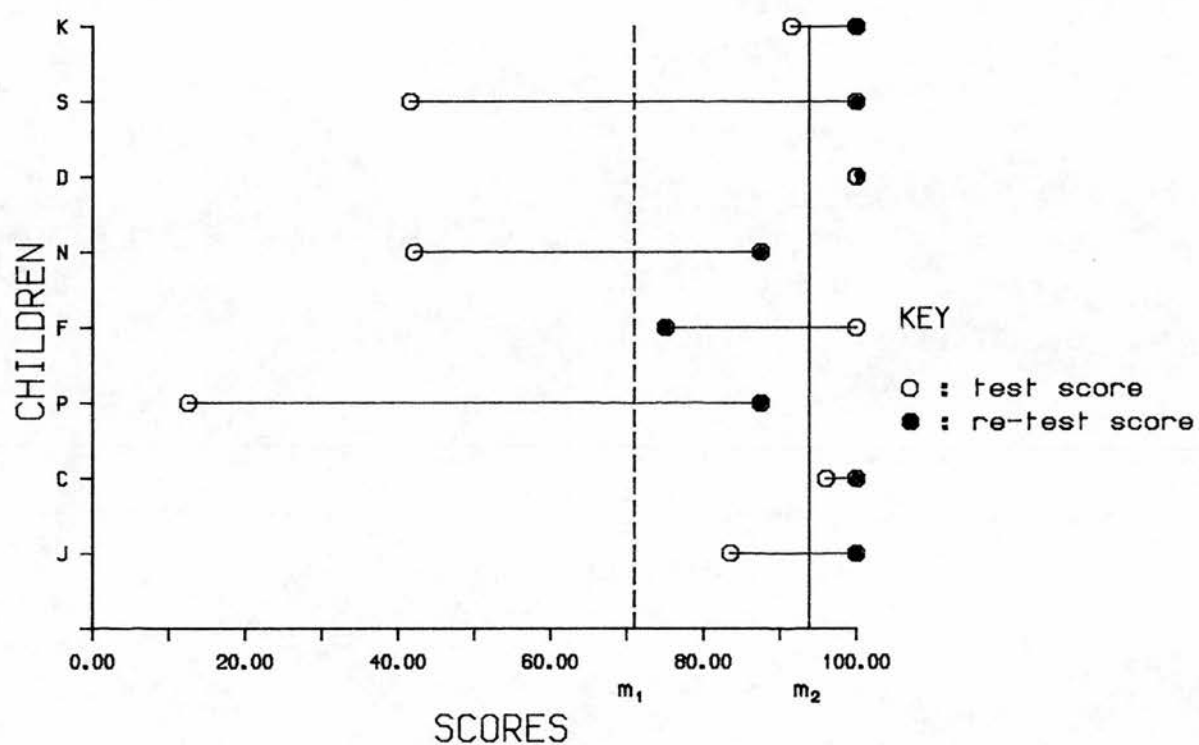
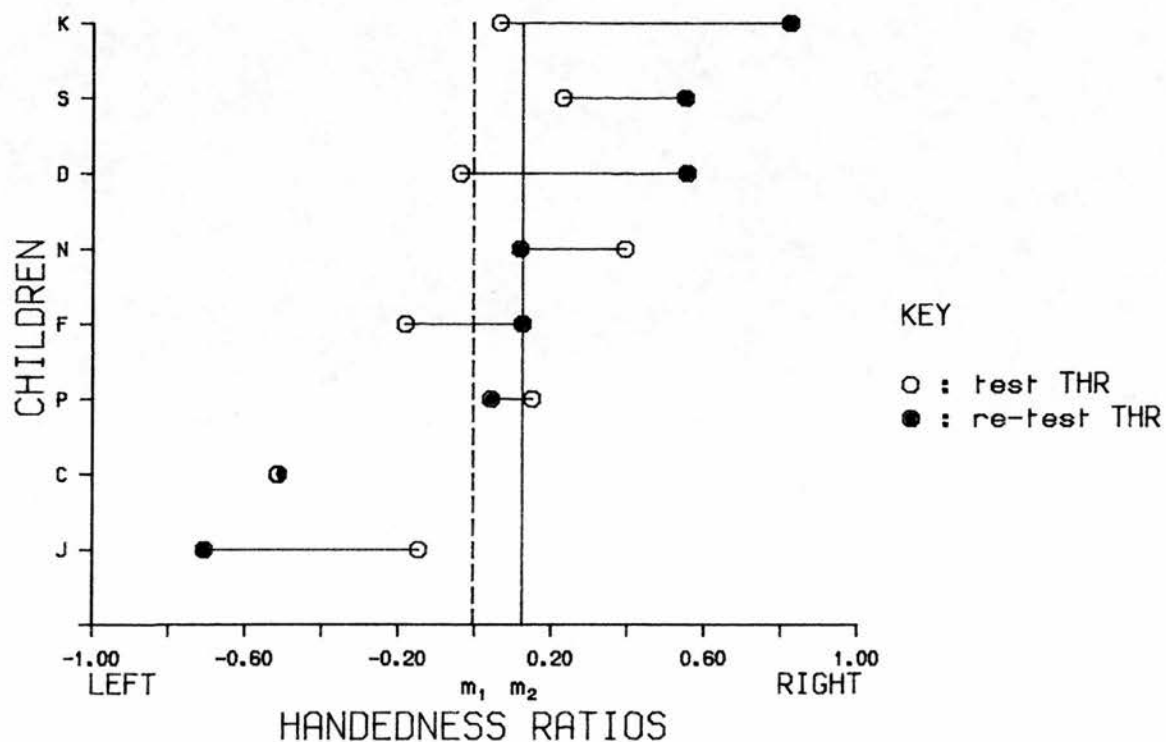


Figure 2.3b
TEST AND RE-TEST HANDEDNESS RATIOS



In Figure 2.3, the eight children's earlier and later Tasks 3 and 4 scores (2.3a) and handedness ratios (2.3b) are plotted. The children, identified by the first letter of their pseudonyms, are in the order of their later handedness ratios, the left-most at the bottom to the right-most at the top. These distributions show the following patterns:

- The later THRs correspond to the children's categorical handedness: The three that are left of that year's mean (m_2) are those of the left-handed child (Judy) and the two ambidextrous boys (Calum and Patrick); the more rightward THRs are those of the categorical right-handed children. (The two nearest the mean are those of the oldest and the youngest children, Fiona and Natasha -- the one hearing, the other deaf.)
- The least change in the children's handedness ratios one year later is for the ambidextrous children ($m=.055$). The greater change in the others' ratios ($m=.470$) is, with one exception, in the direction of the children's categorical handedness -- more to the right for four of the five right-handers, more to the left for the one left-hander. (The outward shifts for four children are so great that the later ratios on both tasks, not just the means of the two, are greater than the earlier ratios.)
- Among the right-handers, the mean for the deaf children is still more rightward, by .2, than for the hearing children; the most rightward again is that of a deaf child (Keith). Of the ambidextrous children, the THR of the deaf boy (Patrick) is also the more rightward, by .6.
- The only children whose re-test scores on Tasks 3 and 4 are not 100% are the three children whose handedness ratios are nearest the mean. Not only are these scores low for the two who are deaf but also their total test and re-test scores are the lowest of all eight children. Another way in which these three children differ is that they are the only ones in this sample who are not first-borns. A further coincidence is that the one task on which each had the lower score is the task on which his ratio is nearer the mean (see Table 2.8).

Table 2.8: LOWER SCORES AND NEARER-MEAN HANDEDNESS RATIOS

	Task 3 re-test		Task 4 re-test	
	Score	THR	Score	THR
Patrick	75	-.017	100	.100
Fiona	100	.250	50	.000
Natasha	75	-.111	100	.347

In conjunction with the association of a more leftward ratio

and a *higher* score, as seen before in the testing of all the Preliminary Study children, a *nearer-mean* ratio is associated with a *lower* score. Looking back at the score-ratio plot for the 20 children (Figure 2.2), we can see a cluster of low scores at the middle-right of the THR scale.²⁰ With handedness more specialized -- either more left-handed or more right-handed, the scores of these children are higher; the more mixed handedness, associated with lower scores, suggests not a complement but a conflict.

SUMMARY

In this sample, the 10 hearing children and the 10 deaf children showed similar abilities on three sequencing tasks: recalling the order of storybook pictures (Task 2), repeating clapping patterns (Task 5), and imitating series of three actions (Task 6). On the other three tasks, the performance of the hearing children was significantly superior. Requirements of these tasks were to determine the temporal order of events in three-part sets of picture cards (Task 1), to arrange cutouts in a progression from the smallest to the largest (Task 3), and to continue three-part shape patterns (Task 4).

There were no differences in the scores of four hearing and four deaf children when they were re-tested one year later. Although there was a ceiling effect, the re-test scores of the deaf children on Tasks 1, 3, and 4 were exactly the same as the *first* test scores of the hearing children on those three tasks, and the hearing children's first lower scores on Task 2 rose so their and the deaf children's re-test scores on this task were identical (although still the lowest of the six tasks for both groups). It would seem that the deaf children are not different from the hearing children, but rather that

²⁰When the single far-right THR is withheld, the significance of the correlation of the ten left-of-mean and nine mid-right ratios with the scores is not affected ($r_s = -0.60$ versus -0.61 , $p < .005$, with Tasks 3 and 4 scores; $r_s = -0.56$ versus -0.55 , $p < .01$ with the total scores).

their step to the music they cannot hear is different.

The hand use of the 20 children was a differentiating factor: Higher scores correlated significantly with greater left-hand use. From the re-test data, it was seen that as the children's scores increased, the ratios of the left- and right-handed children became more extreme; lower scores were associated with the nearer-mean handedness ratios on those tasks. Thus, with these tests and measurements, an analogue of the children's mental improvement is their manual specialization, with both apparently related to developmental age.

Three other factors -- age, familial left-handedness, and birth order -- were also related to test scores: On each of the six tasks, scores correlated positively with age and were higher for those with than those without a familial 'left factor' and for those who were first-born children. Of these factors, only first-born status related significantly to total scores.

The results of the Preliminary Study raise questions: With a greater number of children tested, would the results be similar? Would an 'Assist' category added to the Placement and Collection contacts with the materials afford new interpretations? If durations rather than frequencies of contacts were used, if midline crosses and transfers were analysed, if sequential and simultaneous movements were differentiated, would different thought processes be clarified? When types of errors and discourse are described, what else might we learn about what the children know? The Main Study, reported in the next four chapters, was conducted to try to answer these questions.

CHAPTER 3

MAIN STUDY

As my two eyes make one in sight.

Robert Frost
(Two Tramps in Mud Time)

The intent of the Main Study was to explore the results of the Preliminary Study with a greater number of children within a larger age range. By tripling the total number of children tested and having twice as many hearing as deaf children, reliability of consistent results would increase and subgroups of matched deaf-hearing pairs could be studied. Other additions would provide greater scope -- in depth, by extending the sets of the tasks on which there were significant differences between the deaf and hearing children, and in breadth, by supplementing the hand use data with an inventory of the children's hand, foot, and eye preferences (Appendix H).

Among all the children, the test scores correlate positively with age and are significantly higher for those who can write their names. The left-handed and ambidextrous children scored higher than the right-handed children on all the tasks, significantly higher on one. When adjusted for age, the scores of the hearing children and the first-born children are also significantly higher. There are no statistical differences between the boys and the girls on any of the variables studied.

SUBJECTS

Sixty children, 40 hearing and 20 deaf, were tested in the Main Study. As in the Preliminary Study, half of the hearing children were from the Psychology Department nursery, the other half from the local nursery school that had participated previously. Of the deaf children, two were from the residential school in England that children in the Preliminary Study attended; the others were from schools in Scotland -- 11 at a residential school and seven at day schools for the deaf.

All but the six children attending one of the day schools are in total communication programs.

Complete information about only eight of the deaf children was available. (Records of Needs had not been completed for six children, and for the other six, information was considered confidential.) The eight children, all in total communication programs, are profoundly deaf, with a hearing loss from 95 dB to 108 dB ($m = 104$ dB) in the unaided better ear. The other children are said to meet the criterion of at least a 70 dB loss. The aetiologies reported for the 20 (congenitally) deaf children are hereditary factors for 35%, other genetic factors for 10%, perinatal insult for 15%, and unknown for 40%. Two pairs of the deaf children are siblings; their parents, a parent of two other children, and the sister of another child also are deaf. Two of the deaf children have a visual impairment.

One deaf child was adopted, and is the youngest of the four children in her adoptive family. There was no information about her natural parents, or about the father of two other deaf children and three hearing children (for whom familial handedness data are, therefore, maternal only). Three deaf children are of an ethnic minority; the one who is Chinese is bilingual, and one of the two who are Pakistani is trilingual in spoken communications. Three hearing girls have a parent who is Chinese; two of them (twins) and two other hearing girls are bilingual (in English and French and in English and Hungarian). Two other hearing girls included in the study are twins, and one deaf boy has a hearing twin brother. This information is included in Table 3.1, along with other characteristics of the 40 hearing and 20 deaf children.

Table 3.1: MAIN STUDY CHILDREN

	Hearing Children (n=40)	Deaf Children (n=20)	Total (n=60)
Age			
Mean	4:1	4:10	4:4
Median	4:1	4:9	4:2
Range	3:0-5:0	3:1-7:6	3:0-7:6
Sex			
Female	21	7	28
Male	19	13	32
Sibling rank order			
First-born*	17	7	24
Second--	19	12	31
Twin	4	1	5
Handedness			
Right	34	17	51
Left	4	3	7
Ambidextrous	2	0	2
'Left factor'	25	14	39
No 'left factor'	15	6	21

*Four hearing children and two deaf children had no siblings.

The differences between the hearing and the deaf children in these categories are all statistically insignificant (from M-W $U=298$, $p>.1$, for hearing status by age to M-W $U=400$, $p=1$, for hearing status by handedness).

The age range is greater and the mean age is nine months older for the deaf than for the hearing children. Eight deaf children are older than the oldest hearing child. This age skew, necessitated by the demographic scarcity of deaf children, was considered an advantage. From results of the Preliminary Study, the age difference was expected to (and did) create a more equal score distribution among the deaf and the hearing children.

That there were almost twice as many deaf boys as deaf girls reflects the actual sex ratio in the four schools of these deaf children. To obtain 20 prelingually deaf subjects at the time of the study, it would not have been possible to select equal numbers of deaf girls and boys without including more schools or extending the age range further.

The children's categorical handedness is that reported by the parents (on the questionnaire in Appendix F) and confirmed by the teachers. When the reports were conflicting, regarding ambidexterity, the ratios from the handedness part of the

Handedness-Sidedness Inventory (the IHRs) and from the sequencing tasks (the THRs) determined the classification.

One of the two children categorized in the study as ambidextrous is the only child considered ambidextrous by both parents. The mother of the other child ticked 'ambidextrous' and added "with left hand preference"; his father ticked 'left-handed', adding "and uses right too".¹ Both these children categorized as ambidextrous have THRs and IHRs that are left of the means.

For four other children, uncertainty about ambidexterity also was indicated, with one parent differing from the other parent, adding a question mark or "not sure" comment with examples, or altering his choice. However, because these four children have right-of-mean IHRs, two (not the two visually-impaired deaf girls) also right-of-mean THRs, and because seven of the children reported to be right-handed have both IHRs and THRs that are left of the means, these children were all classified as right-handed. They all wrote (or attempted to write) their names with their right hands.

¹This child wrote the first two letters of his name (just left of the middle of the page and his body) with his left hand, then transferred the pen to his right hand, with which he wrote the other two letters. It is reproduced below with the permission of his parents.

SCORE SHEET



During the Handedness-Sidedness Inventory, he began his drawing (of his dad) with his right hand and completed it with his left hand; prompted additions of arms and hair were drawn with the slate upside down. His Inventory ratios are exceptional in their consistency: He is the only child who has negative (left-sided) ratios on all three counts (-.286 for hands, -.333 for feet, and -1 for eyes). The ambidextrous girl wrote her name with her left hand; she drew circles on the board first with her left hand, then with her right hand.

Curiously, of the six children whose reported handedness is bimanual, four are bilingual; their representation among all the bilingual children in the study is the same, 67%. The one categorically ambidextrous girl is bilingual and is also a twin.

Within the handedness categories, there is absolutely no hearing status bias. As in the total population, the hearing-deaf ratio among the right-handed children and among the left-handed/ambidextrous children is two-to-one. Exactly 15% of the hearing and the deaf children are left-handed/ambidextrous.

Including the information available on the handedness of others in the family, 66% of 56 children in this study have a 'left factor', i.e. the children are left-handed/ambidextrous and/or have at least one relative who is.² The proportions of hearing and deaf children with a left factor are similar, 64% and 71%, respectively.

TASKS

The Main Study test is composed of the three sequencing tasks of the Preliminary Study that significantly differentiated the skills of the deaf and hearing children, including the two tasks from which handedness ratios were obtained. Details of these three tasks, their scoring and administration procedures are described in Chapter 2, with the Main Study alterations

²This 66% and the 75% representation of the children in the Preliminary Study who have a left factor both exceed the 42% of the University students surveyed who have a left factor (see Appendix C). It would seem to be chance that the proportions are inverse to the numbers of subjects in each study. Because of the similar age of the parent and student respondents, the differences probably reflect more upon differences in the populations sampled than upon changing attitudes and practices and a concomitant increase in the incidence of left-handedness/ambidexterity.

noted within square brackets there and explained below.³

Task A, Picture Sequences, consists of the demonstration set and test sets 1-3 of Task 1 in the Preliminary Study plus one other three-part set and two two-part sets. Two longer sets, of four and five pictures, were added if at least three of the sets 1-6 had been completed correctly (or upon the child's request).

Task B, Size Progressions, is the same as Task 3 in the Preliminary Study.

Task C, Pattern Continuations, has the same demonstration set and first test set as in Task 4 of the Preliminary Study. Substitutions were made in the second test set to avoid any confusions from replication of shapes included in set 1. (The small yellow triangle was replaced by a small green triangle and the large yellow triangle as the trick shape was replaced by a small white circle.) An additional, third, set consists of three shapes with the shapes and sizes varied but with the colour constant.

In the Main Study, no classroom teacher was present during the testing of any of the deaf children; however, the head teacher of one hearing nursery class accompanied a few of the very young children, staying until assured they were comfortable with the testing situation.

The 60 Main Study children completed all the tasks, which were presented in a random order. Again there appears to be no effect of presentation order on scores. As shown in Table 3.2, whether a task was presented first, second, or third, the

³An attempt to administer the test nonverbally failed. Having the examiner mute, miming the demonstration apple sequence and the instructions, was a bewildering, evidently unnatural charade for the trial subject, a hearing child. After five minutes of guessing, and ceasing to smile, Ben said, "I want to go back to the nursery now." The testing for him -- and the experiment -- ended. Thus, as in the Preliminary Study, the examiner used gestures only as a supplement to speech, reinforcing but not violating the children's natural modes of communication.

highest and the lowest scores are distributed evenly. The only difference of greater than two is the high number of perfect scores on Task B when presented second (53%).

Table 3.2: TASK PRESENTATION ORDER OF HIGHEST AND LOWEST SCORES

Highest scores (at 100%)	Order of Presentation		
	1st	2nd	3rd
Task A (n=6)	2	2	2
Task B (n=15)	3	8	4
Task C (n=13)	4	5	4
Lowest scores			
Task A (n=11) (at 10% or 20%)	4	4	3
Task B (n=7) (at 17% or 25%)	3	2	2
Task C (n=12) (at 0%)	4	5	3

For these children, the total testing time averaged 34 minutes (34 minutes for the hearing children, 36 minutes for the deaf children), ranging from 22 to 50 minutes (both extremes the times of hearing children).

TEST RESULTS

Table 3.3: SCORES OF THE MAIN STUDY CHILDREN

	Hearing Children	Deaf Children	Total
Task A			
Mean score	50%	39%	46.3%
Median score	40%	40%	40.0%
Score range	10-100%	10-100%	10-100%
Task B			
Mean score	75%	58%	69.0%
Median score	92%	58%	75.0%
Score range	17-100%	17-100%	17-100%
Task C			
Mean score	57%	48%	54.1%
Median score	67%	50%	67.0%
Score range	0-100%	0-100%	0-100%
Tasks B and C			
Mean score	66%	53%	61.6%
Median score	68%	51%	66.0%
Score range	8.5-100%	8.5-100%	8.5-100%
Tasks A-C Total			
Mean score	61%	48%	56.5%
Median score	56%	52%	55.5%
Score range	15.7-100%	9.0-100%	9.0-100%

With the mean and median scores of all the children on the three tasks together slightly above 50%, these scores can be an index of sequencing task skill, the 29 children scoring

above them showing from partial to total comprehension of the task requirements, the 31 scoring below them showing insufficient comprehension. (Coincidentally, the mean total score of the children in the Main Study is identical to that of the children in the Preliminary Study, 56.5%.)⁴

Scores in relation to hearing status. The total scores of the hearing children are not significantly higher than the total scores of the deaf children (M-W $U=295.5$, $p>.1$). The proportions of deaf and hearing children with above- and below-mean scores illustrate their similarities: Exactly half of the deaf children and one short of half of the hearing children scored above the mean (chi-square $p=1.000$).

As shown in Table 3.3, the scores on each of the tasks have an identical range for the deaf and the hearing children, but on each task the mean score of the deaf children is lower, with their scores significantly lower on Task B, the Size Progressions (chi-square $p<.01$). Task B, nevertheless, is the task on which the hearing and the deaf children have their highest scores. The lowest scores for both groups are also in agreement, on Task A.

Comparisons of the scores of the deaf children by educational programme (one oral and three total communication programmes) are complicated by other differences between the two groups, including the following disproportionate representations.

- Total numbers: Only six (30%) of the deaf children are in an oral programme.
- Age: The total communication children are one year older than the oral deaf children (by both mean and median ages).
- Handedness: One of the total communication children (7%)

⁴The numbers of children who scored above the means are 23 on Task A, 31 on Task B, and 36 on Task C. Respectively, for the left-handed/ambidextrous children they are five, five, and eight, and for the deaf children are five, five, and ten.

but two of the oral deaf children (33%) are left-handed.⁵

- Aetiology: Only within the category of 'unknown cause' is there an equal number of total communication and oral deaf children (four each). Hereditary deafness and perinatal insults are the ascribed cause of deafness for only total communication children, other genetic factors for only oral deaf children.

Some of these biases favour the total communication children, whilst others favour the oral deaf children. The data are presented and discussed in the next sections.

Scores in relation to age. Age is a decisive factor influencing the children's scores. The total scores correlate positively with age ($r_s=0.55$, $p<.001$). Of the three tasks, the highest correlation is with Task C ($r_s=0.53$, $p<.001$), the lowest with Task A ($r_s=0.24$, $p<.05$).

To determine the absolute difference in the scores without the influence of the age factor, favouring the deaf children, the total score of each of the 60 children was converted to a ranked Age-Score Differential (ASD). These age-adjusted scores were computed by subtracting the child's age rank (of one for the youngest child) from his inverted score rank (from 60 for the highest score to one for the lowest score), with tied scores ordered by age. For example, Joel ranked 27th from the youngest child and is the youngest of the three children who have a perfect total score; therefore, $60 - 27 =$

⁵By the Inventory Handedness Ratios, discussed in the next chapter, equal numbers of children in both groups preferred to use their left hands (four each) or their right hands (two each); however, eight of the total communication children but none of the oral deaf children showed mixed handedness.

33, his ASD.⁶

The high ASDs of the hearing children differ significantly from the low scores of the deaf children (M-W $U=182.5$, $p<.001$). Only two (10%) of the deaf children but 26 (65%) of the hearing children scored above the mean (chi-square $p<.0005$).

The hearing-status difference is seen in the scores of the younger and the older children. There is no significant difference in the ASDs of the younger and the older hearing children (M-W $U=151.5$, $p>.1$). However, among the deaf children, there is a significant difference (M-W $U=9.5$, $p<.002$); nine of the 10 top deaf scorers are younger than the deaf mean and eight of the 10 bottom deaf scorers are older.

Differences in the deaf children's ASDs, their aetiologies and educational programmes are shown in Table 3.4.

⁶Two other measures were used to verify the reliability of the ASDs: the residuals of a resistant line regression and the residuals of a least squares regression. There is no significant difference between the ASDs and either of the other measures (Wilcoxon $p=.895$ and $.906$, respectively). For example, the above-mean and below-mean scores by all three age-adjusted methods are in agreement for 47 children (78%); for three children, there is agreement between the ASDs and one of the residuals. Of the ten children whose above- and below-mean ASDs disagree with both other measures, seven are hearing and three are deaf; for four children the ASDs are lower and for six they are higher. Their ASDs are very close to the mean, deviating by an average of 2.7 points, an insignificant amount considering that the overall range is -43 and +33 points from the mean. These even distributions, by hearing status and by above- and below-mean scores, and the fact that the few discrepant scores are borderline augment the validity of the ASDs for further analyses.

Table 3.4: ASDs, AETIOLOGIES, AND EDUCATIONAL PROGRAMMES OF THE DEAF CHILDREN

	ASD (Deaf Rank)		Educational Programme
Unknown cause (40%)			
Samuel	15	(1)	oral
Anthony	13	(2)	TC
Warren	0	(3)	TC
Ali	-10	(10)	oral
Simone	-11.5	(11)	oral
Gayle	-12	(12)	TC
William	-16	(15)	oral
Miranda	-21	(17)	TC
mean	-5.3	(8.9)	
Genetic:			
Hereditary deafness (35%)			
Duncan	-1	(5)	TC
Alice	-1	(6)	TC
Robert	-2	(7)	TC
Alan	-2.5	(8)	TC
Jessica	-10	(9)	TC
Daniel	-13	(13)	TC
Imran	-21	(18)	TC
mean	-7.2	(9.4)	
Other (10%)			
Arthur	-1	(4)	oral
Ellen	-16	(14)	oral
mean	-8.5	(9)	
Perinatal insult (15%)			
Bruce	-18	(16)	TC
Tarini	-36	(19)	TC
Jimmy	-43	(20)	TC
mean	-32.3	(18.3)	

Left-handed children

The aetiology of deafness is important because there is a greater probability of additional defects, including various central nervous system disorders, when the deafness is of a nongenetic origin (e.g. prematurity, jaundice, rubella, and meningitis) than when the the deafness is hereditary (Mindel and Vernon 1971). The three children reported to have been deafened perinatally, with prematurity and jaundice as the nongenetic causes, do have age-adjusted scores within the lowest quartile; two are the lowest of all the children in the study. In contrast, of the seven children whose reported cause of deafness is hereditary, five (71%) scored above the mean. These results conform to the expectations of cognitive

ability with respect to aetiology.⁷ (See Appendix D for a discussion of the academic, as well as social, superiority of deaf children whose families also are deaf.)

Furthermore, as unidentified hereditary factors are thought to constitute a portion of those aetiologies reported as 'unknown', they could contribute to the higher mean scores of the children within the 'unknown' group.

It is in this group of deaf children whose aetiologies are unknown that there is an equal number of total communication and oral children, allowing a comparison of the age-adjusted scores by educational programme, i.e. with constants of number, age, and aetiology (but not handedness). The difference in scores is insignificant: The mean ASD is -5.0 for the four total communication children and -5.6 for the four oral deaf children. (Among all 20 deaf children, both the total communication and the oral children are divided equally by above- and below-mean/median ASDs and total scores.)

For reckoning differences in the deaf children's scores by handedness, the 15 children with unknown and hereditary aetiologies, and similar ASDs, can be combined. Of these children, the mean ASD for the three left-handers is seven points higher, -0.7 versus -7.6 for the 12 right-handers. (See the later section of this chapter about the categorical handedness of all the children, and the following chapter about the inauspicious association of particular handedness

⁷Recall that in the Preliminary Study the one child with a confirmed diagnosis of nongenetic origin (meningitis) is that study's lowest scorer, and the two children whose re-test scores are the highest are both genetically deaf. The two studies, with compatible results, can together be considered representative regarding aetiology: Genetic and 'unknown' causes of deafness are consistently reported in close to 50-50 proportions; of the 30 deaf children in these studies, genetic factors account for the deafness of 12 (40%), unknown factors for the deafness of 14 (47%). The 13% incidence of deafness attributed to nongenetic peri-/postnatal insults (for four of the children) is comparable to its 11-16% incidence reported over 20 years in the United States (Brown 1986).

ratios with aetiology, educational programme, and lower scores.)

Thus, the low scores of the children whose deafness was caused by insults at birth are the most differentiated. Specific aetiology appears to be a more decisive factor than educational programme.

Scores in relation to birth order. Another significant differentiation of the ASDs is with birth order (M-W $U=247.5$, $p<.01$): The first-born children in this study have the higher age-adjusted scores, as among the similar-aged children in the Preliminary Study.⁸ Of the children who scored in the top and bottom quartiles, nine (60%) and two (13%), respectively, are first-borns. A still greater contrast is that eight of the nine top scorers but none of the nine bottom scorers are first-born children.

Scores in relation to name-writing ability. A skill generally associated with age is writing. For theoretical and practical reasons, a child's ability to write his name seemed relevant (besides being an immediate index of handedness): Along with spoken and sign languages, writing is an abstract, symbolic system of communication. It is a complementary skill to reading (which together with arithmetic and reasoning comprise the basic four 'R's) and is an early skill that necessitates a linear, left-to-right, ordering. Without having mastered this way of expressing a conventional orientation, might a child be less able to master -- even comprehend -- other sequential tasks? An association between name writing and sequencing task success was indicated in the scores of the Preliminary Study children: Seven of the eight children whose scores were the highest could write their names, whereas only half of the other children could.

⁸Of the five children who are twins, one scored (just) above the mean, 19th among the 40 hearing children; the other twins scored among the 11 lowest hearing children and the lowest of the deaf children.

In the Main Study, the top 18 scorers were all able to write their names independently; the 12 lowest scorers could not, either independently or with a model. All these lowest scorers are younger than the mean. However, seven (39%) of the top scorers also are in the younger age group. For the 60 Main Study children, the highly significant relationship between total scores and name writing ability (M-W $U=87.5$, $p<.0001$) is similar to but stronger than the relationship between age and name-writing ability (M-W $U=120$, $p<.0001$).

Table 3.5: AGE AND NAME WRITING ABILITY IN RELATION TO SCORES

	Age		Name Writing Ability	
	- mean	+ mean	No	Yes*
			[Age - mean, + mean]	
Total scores below the mean (n=31 children)	26 (84%)	5 (16%)	22 (71%) [21,1]	9 (29%) [5,4]
Total scores above the mean (n=29 children)	11 (38%)	18 (62%)	2 (7%) [1,1]	27 (93%) [10,17]
Chi-square p	<.001		<.0001	

*Independently or in imitation

As shown in Table 3.5, the children's low scores are associated with their being young (84%), while the children's high scores are associated with their being able to write their names (93%). Of the 29 children who scored above the mean, only two could not write their names at all.⁹ That all but one of the 11 younger children who had higher scores were able to write their names, and only the one older child who had a higher (but borderline) score could not write her name, accentuates the relevance of name-writing ability. It would seem beneficial for writing to be taught early, beginning with the child's own name, for development of his self concept as

⁹One higher scorer who could not write her name ranked 19th from the top, is younger than the mean and is hearing. The other, who ranked 29th (her score of 57 being just .5 above the mean), is older and is deaf. This deaf girl had been in a total communication programme for only six months. The other eight older children in a total communication programme could write their names independently, while neither older child in the oral programme could write his name without an example to imitate.

well as for development of sequencing and elementary reading skills.

Scores in relation to sex. The sex of these children is an irrelevant factor, influencing neither the scores (whether total or age-adjusted) nor any other variables studied -- not hearing status, age, sibling rank order, handedness (by absolute category or by relative performance), or name-writing ability. (The Mann-Whitney two-tailed level of significance is .204 for sex by hearing status and greater than .675 for sex by all the other variables, e.g. .994 by total scores and .818 by ASDs.) There is, however, within the hearing and the deaf groups a difference, a success reversal: 62% of the hearing girls but 62% of the deaf boys scored above the respective hearing and deaf ASD means. With 42% of the hearing boys and 29% of the deaf girls scoring above the means, it is the deaf girls who are the least represented among the higher scorers.

Scores in relation to categorical handedness. All the scores -- the ASDs, total scores, and the scores on each task -- of the left-handed children, and the left-handed and ambidextrous children together, are higher than the scores of the right-handed children. The difference is significant on Task C, the shape pattern continuations (M-W $U=91$, $p<.05$, and M-W $U=121$, $p<.05$, respectively for the left-handers alone and for the left-handers and ambidextrals versus the right-handers). Task A and total score differences between the left-handed and right-handed children approach significance (M-W $U=107.5$, $p<.1$, and M-W $U=102.5$, $p<.1$, for the respective scores).

The total scores of all but one of the left-handers (86%) are above the mean, a two-times greater representation than among the right-handers, 43% of whom have above-mean total scores

(chi-square $p < .05$).¹⁰ The total scores of the nine left-handed/ambidextrous children average 17 percentage points above the average for the right-handed children; four (44%) of the nine have perfect scores on two tasks, in contrast to 10% of the right-handers. The superior scores of the left-handed and ambidextrous children are independent of age: Their mean age is 4.35; the mean age of the right-handers is 4.37.

Compatible with the results of the Preliminary Study, the children in the Main Study who have a 'left factor' (i.e. are themselves left-handed/ambidextrous or have a relative who is) scored higher on all three tasks, particularly on Task C, than the children who have no left factor. Again most (four of the six) children who have the lowest ASDs also have no left factor. (The 67% for the Main Study lowest scorers without a left factor contrasts to the similar 66% of all the Main Study children who have a left factor.) However, in the Main Study, the only difference that approaches significance is that between the familial handedness and the age-adjusted scores of the deaf children (M-W $U=13$, $p < .1$): Of the 17 deaf children for whom complete familial information was available, 50% of those with ASDs below the deaf mean but 89% (8 of the 9) with ASDs above the deaf mean have a left factor.

The relationship of the children's scores to their handedness ratios and patterns when doing the tasks is discussed separately, in the following two chapters.

ERRORS

In general, faults were to place the objects in the order of contact instead of in regard to a principle, to place them in

¹⁰As in the Preliminary Study, the one left-hander who has a below-mean score is a hearing girl. She is also the only left-handed/ambidextrous child who was not able to write her name. This 11% contrasts to 45% of the right-handers who could not write their names (chi-square $p < .05$ for the left-handed/ambidextrous versus right-handed children who could write their names independently, with a model, or not at all).

a line from left to right only when prompted, to match them by similarities, and to make no changes in the original placements (either by exchanges or by, especially resisted, insertions). Instructions and demonstrations were ignored. Actions were immediate and impulsive, evincing little restraint or deliberation.¹¹

In Task A, errors are associated with a child's responding as though the instructions had been simply to turn each card over and to describe each in isolation, without relating each one to the others. (Examples of the children's language when describing the events in the pictures are given in Chapter 7.) In Task B, rather than seriate all the objects from smallest to largest, i.e. in an asymmetrical pattern, binary combinations were selected. For example, pairs of similar sizes were placed together -- particularly with the largest two objects centred, creating an approximately symmetrical array. Another choice was to separate the three smallest objects from the three largest objects, with the order random in each half. In Task C, if the shapes were not merely strung out from the top to the bottom of the pile, those shapes of the same colour, size, and shape attributes were placed

¹¹Such errors correspond to two types of structural seriation errors, of 10- to 14-year-old children, described by Donaldson (1963). One error, referred to as 'incomplete elimination', is when conclusion is premature. Other, alternative, possibilities have not been considered. A child might lack awareness of the total structure of the problem, of the need to systematically and thoroughly apply a superordinate principle. Another lack might be of the rigour necessary to sustain attention or to adhere to an external mandate. Conversely, what is present is impulsivity -- a trait, like inattention, ascribed to children in general and to deaf children in particular (e.g. Myklebust 1964). Choices are inclusive (as if to say "I'll have that one and that one and that one"). If an appropriate strategy had been adopted but was later abandoned ('principle abortion'), this atavistic assertion may involve a compromise (e.g. "I did those your way -- now I'll do these my way"). The associated error is a 'loss of hold', a failure to hold information in abeyance. With the shape patterns, for instance, 'hold' involves negations and affirmations (e.g. "Not red, not blue; yes, yellow") as well as at least implicit reiteration of the model order (e.g. "red, yellow, blue" or "circle, square, triangle"). For the children whose strategies fail, affirmation, addition, and sameness prevail over their opposites -- the necessary element of negation, subtraction, and difference. Also a deficit observed is in the degree of control and ability to suspend decision.

together. (A residual 'sameness' predilection emerged also in the collections of some children whose placements had been correct.¹² Visual references to the stimulus sets were absent or minimal.

Of the children who made errors, those who accepted the order of the materials presented to them, merely placing items on the board in the order of contact, without examination or regard for any principles of selection, responded in a pre-autonomous way common to young children (whose uncritical inclusiveness -- even of contradictions -- is documented by Piaget and Donaldson) and with a sense of powerlessness similar to Schlesinger's (1985) descriptions of deaf people and their families (and suggested in the questionnaire responses of the parents of deaf children in this study, reported in Appendix C).

A higher-order response of others who made errors was to devise their own rules, as if to make some sense of the tasks, and to show (off) what they did know. With either response, the children appeared to be doing what pleased them, in a Piagetian 'egocentric' manner.¹³ It seemed that when the task examples were relevant to the children's past learning experiences (perhaps through games or classroom exercises),

¹²This sort of regression, or retention, was recognized by Piaget (e.g. 1959) when he stated that earlier stages are not necessarily relinquished, but rather sometimes co-exist with progressions to later stages. For example, when a child in the Preliminary Study was first tested, he simply juxtaposed shapes of the same attributes together, in five pairs and one triplet (for a score of zero). When re-tested one year later, he correctly repeated the set patterns (and scored 100%) -- but only after preliminary sortings of the same shapes into piles (a procedure that was uniquely his).

¹³Applicable also to these children are Piaget's (1959) words describing the 'ego-centric groove' of a young child's thought processes: his being 'shut up in his own point of view', his being 'satisfied' in his belief that he both understands and is understood and that 'nothing is impossible', his being 'insensible to contradiction'; his ability to 'always find a justification for everything', his dependence upon the familiar with disregard of the unknown, assimilating 'everything he hears to his own point of view and to his own stock of information' -- basically, his 'lack of differentiation'.

then their intentions did coincide with, and their actions did conform to, the instructions.

To analyse the types of errors the children made, absolute scores were used. Credit was given for sets that were completely correct; no credit was given for sets that had at least one error. Results are shown in Table 3.6, with a comparison to the scores previously reported, when partial credit was given (for correct units, e.g. of correct picture-sequence pairs, size ordinal positions, and shape triplets).

Table 3.6: ABSOLUTE SCORES ON TASKS A-C

	Task A (Sets 1-6)		Task B (Sets 1-2)		Task C (Sets 1-3)		Total (Tasks A-C)	
	H	D	H	D	H	D	H	D
<u>Number of children</u>								
With no errors	5 (13%)	<u>6</u> 1 (5%)	13 (33%)	<u>15</u> 2 (10%)	10 (25%)	<u>13</u> 3 (15%)	2 (5%)	<u>3</u> 1 (5%)
With errors in fewer than half the sets	6 (15%)	<u>6</u> 0 (0%)	9 (23%)	<u>14</u> 5 (25%)	17 (43%)	<u>23</u> 6 (30%)	21 (53%)	<u>27</u> 6 (30%)
With errors in half or more of the sets	29 (73%)	<u>48</u> 19 (95%)	18 (45%)	<u>31</u> 13 (65%)	13 (33%)	<u>24</u> 11 (55%)	17 (43%)	<u>30</u> 13 (65%)
With below-mean unit scores	22 (55%)	<u>37</u> 15 (75%)	14 (33%)	<u>29</u> 15 (75%)	14 (35%)	<u>24</u> 10 (50%)	21 (53%)	<u>31</u> 10 (50%)

H = hearing; D = deaf
(percentage H/H and D/D)

With each way of scoring, the results are similar: On each task, proportionately more deaf than hearing children scored below the mean (significantly on Task B) and made more absolute errors. Although the total scores already reported do not differentiate the deaf and the hearing children, the absolute scores show a difference: Of the children whose total scores are below the mean, all ten deaf children made errors in half or more of the sets on every task, but six (29%) of the hearing children made errors in fewer than half the sets on one task (three of them having no errors on that task).

When the absolute errors were further analysed, an additional difference was seen in the types of errors the children made:

The hearing children tended to make 'better' errors. These errors demonstrate a step beyond recognition of simple similarities, e.g. that although four shapes are red, they have a positional relationship to the four that are blue and the four that are yellow. 'Worst' errors are those that show no sorting by similarities; objects were placed on the board from the first contacted to the last, in a line if that rule was apprehended (or, with prompts, accepted).

Steps in the progression of errors accord with three rules:

1. A 'same' rule: juxtaposing objects of similar attributes (e.g. all the red shapes together).
2. A 'different' rule: separating the objects into groups (e.g. a red, a blue, and a yellow together).
3. A 'same-but-different' rule: ultimately ordering the objects within the groups to match the stimulus pattern (e.g. the blue first, the red next, and the yellow last).

These progressions in the children's errors correspond to perceptions within Piagetian stages of development: The first two steps relate to the progression from syncretistic to analytic thought processes; the last step is associated with the advance to logical reasoning abilities.¹⁴

The progressions seen in the types of errors the children made in the sequencing tasks, Tasks A to C, are recorded in the tables in Appendix B.2. Errors of the hearing and the deaf children are listed separately in the tables and compared in the discussions. Because the hearing children have significantly higher age-adjusted scores, their errors can be used as an index of success -- success based on maturation rather than age.

¹⁴The last step is required in Donaldson's seriation tasks which involve simultaneous operations with extrapolations, "if...then" constructs and relative judgments. Examples are the ability to envisage double memberships and to appreciate that "a given object may be big in relation to certain objects and small in relation to others" (Donaldson 1963, p. 192).

Errors in Task A (Picture Sequences). Proportions of deaf and hearing children who made errors are similar, only slightly higher among the deaf children. The amount of difference on each set averages nine percentage points, ranging from zero on set 6 to 25% on set 4 (the bus sequence).¹⁵ No child made errors only in the two-card sets (either one or both); a similar 49% of the hearing children and 47% of the deaf children who made errors in three-card sets made no errors in either of the two-card sets.

However, a discrepancy, reflected in Table 3.6, is in the total numbers of sets in which the children made errors. Only hearing children made errors in one to two sets (a 15% representation). A higher proportion of the deaf children made errors in three to five sets (averaging 10% higher) -- but not in all six sets. Six hearing children (again 15%) but only one deaf child (5%) made errors in every set. The consistency of errors suggests these, especially hearing, children had some other system(s).¹⁶

The exact repetition of the presentation order is the most common of the five possible misplacement orders of the three cards (in sets 1-4); the next most common is the reverse presentation order, i.e. depending upon whether or not the pile had been turned over. (See the second note in Appendix B.2.) Together these two arrangements account for 53-67% of the misplacements on each of these four sets (versus a chance incidence of 33%). The proportions of the hearing and the

¹⁵Set 6 is also the set that deviated from the other sets in its high incidence of error (two times nearer chance than each of the other sets).

¹⁶Indeed, one child placed (and described and collected) the cards in a left-to-right order with the events ordered 2-[3-]1 in all but one of the sets. (Her descriptions are a clue to her decisions, e.g. placing the two "not painting" and "not broken" pictures together.) Another child placed the last card in the *middle* of all the three-card sets. The other four hearing children placed the cards in the presentation order either exactly (two children) or with one alteration. Only the deaf child's placements have no discernible pattern. (She is Simone, whose actions are described in Appendix G.)

deaf children who repeated the presentation order as given or in reverse do not differ (61.5% and 60% respectively), but they do differ in the number of sets they repeated: Of the children who made errors in Task A, 74% of the hearing children versus 58% of the deaf children repeated the presentation order exactly in one to three of the sets; 11% and 16% respectively repeated the order exactly in four to six of the sets.

Errors in Task B (Size Progressions). Contrasting to Task A, on which the most children (90%) made errors, Task B is the task on which the fewest children (75%) made errors. By absolute errors, as well as by unit scores, the greatest hearing-deaf difference is on Task B -- a difference of 22 percentage points in the proportions of the hearing and the deaf children who made any errors (versus of seven percentage points in Task A and of ten in Task C). The Task B difference is seen particularly in set 2, the dog sequences. All but one of the 45 children who made mistakes on Task B made mistakes in this set.¹⁷

A lower proportion of the hearing than the deaf children made errors in set 2 (65% versus 90%); also a higher proportion of these hearing children made only one error (50% versus 28%) and correctly placed both the smallest and the largest dogs

¹⁷The progressive size difference between each of the dogs is one-third the difference between each of the clowns (1/2 inch versus 1-1/2 inches); while the largest clown measures 10-1/2 inches, the largest dog measures only 4-1/2 inches (the same as the second smallest clown). Also, with the placements horizontal, the length of the dogs is less conspicuous than is the height of the clowns. These size and orientation differences render the seriation of the dogs the more difficult task.

(31% versus 11%).¹⁸ Furthermore, a lower proportion of the hearing children merely repeated the presentation order either exactly or with one alteration (19% versus 44%), and relatively fewer had errors in both sets 1 and 2 (45% versus 65%).

Among all the children, significant differences on set 2 are between the hearing and the deaf children who a) made either no mistake or one mistake (67.5% versus 35%, respectively, at chi-square $p < .05$); b) correctly placed both the smallest and the largest dogs (55% versus 20%, at $p < .05$); and c) did not repeat the presentation order, exactly or with one alteration (90% versus 60%, at $p < .02$).

Additional differences of a few children include only deaf children (three) who placed the clowns and dogs in a nonlinear array on the board (likewise the shapes in Task C by only one deaf child), and only hearing children (three) who spontaneously seriated the dogs and clowns when placing them in the envelopes.

Errors in Task C (Pattern Continuations). By types of errors made in Task C, the differences between the hearing and the deaf children are consistent with the differences on Tasks A and C. Proportionally fewer of the hearing than the deaf children who made errors made 'worse' errors -- those that have little chance of even a partial score (i.e. a point for a correct triplet) and that adhere to a 'sameness' principle: the same order of placement as presentation (27% of the hearing children to 47% of the deaf children) or the same

¹⁸The single misplacement was most often of the largest object, either reversed with the next largest (i.e. 1-2-3-4-6-5, in nine of the 15 adjacent transpositions) or misplaced elsewhere (e.g. 1-2-3-6-4-5), in seven of the 16 in other positions -- in six of the nine other misplacements in set 2). However, no child reversed the smallest with the next smallest object. A 'smallest' salience is further indicated in the accuracy of first and last placements: In spite of other errors, the smallest objects were in the correct position in 50 (66%) of the sets, the largest in only 19 (25%); sets in which either the first or the last object was correctly placed total 33 for the first object versus two for the last object.

attribute matched in at least two pairs or triplets within a set (47% hearing to 65% deaf).

A yet greater difference is seen in the *higher* proportion of the hearing than the deaf children who made 'better' errors -- those that have the possibility of at least a partial score and that infer an awareness of modular 'difference': The most saliently different shape, the large white circle (contrasted to the small blue square and the small green triangle) was correctly centred within the three repetition triplets by seven hearing children and two deaf children (respectively 25% and 12% of the hearing and the deaf children who made errors in the set); the small white circle, the trick shape, was placed last, at the end (the preferred place for 'odd-out' materials [Doré-Lamontagne 1976]), i.e. not disrupting the repetition patterns, by four hearing children and one deaf child (respectively 14% and 6%).¹⁹

A high percentage of both the hearing and the deaf children who made any errors in Task C made what can be considered the 'best' error -- discerning the criterion of 'difference' in the three sample shapes by creating sets of triplets within which the attributes differ, as in the example BRY/BYR/YBR (62%, with 63% for the hearing children and 59% for the deaf children). However, again in a two-times greater proportion, for 12 (63%) of these hearing children and for three (30%) of these deaf children, this was the exclusive error made on any of the Task C sets.

¹⁹The set with the large white circle and the trick shape is set 2, the set on which the most children made errors (all but two of the 47 children who made errors in Task C -- the two exceptions, and the one exception in set 2 of Task B, all hearing girls). Another difference that may be responsible for the greater difficulty of this set is that no attribute is constant: The three shapes are of three different colours and two different sizes. More options may be worse rather than better. Having the choice of operating on any of three parameters might actually obfuscate the task and overwhelm the children. With one attribute constant, e.g. size in set 1 and colour in set 3, the detection and repetition of a pattern might be simpler. The fewer and equal numbers of children who made errors in these two sets (31 children in sets 1 and 3 versus 45 in set 2) lend support to this possibility.

Conclusion: On all three tasks, the relatively superior skills of the hearing children are shown in their greater proportion not only of making no errors but also of making 'better' types of errors.

SUMMARY

The following Main Study results are consistent with, and confirm, the results of the Preliminary Study.

- Scores correlate with age: Scores were higher when children in the Preliminary Study were re-tested one year later; likewise, with different children in the Main Study, the scores of those who are older are significantly higher than the scores of the younger children.
- Scores are not differentiated by sex: On the three tasks that are the same in both studies, there is no significant difference in the scores of the girls and the boys.
- Higher scores are related to left-handedness: Children in the Preliminary Study who used their left hands more predominately and children in the Main Study who are categorically left-handed have significantly higher scores. The children in both studies who have a 'left factor' scored higher on all the sets, while children for whom only right-handedness was reported are among the lowest scorers.
- Higher scores are associated with name-writing ability: Most of the children in both studies who have high scores could write their names, including younger children in the Main Study.
- Scores of first-born children are higher: Among the 20 similar-aged children in the Preliminary Study and the 60 children in the Main Study, whose scores are age-adjusted, the first-born children scored significantly higher than the children who have older siblings.
- The hearing children scored higher than the deaf children: Only the high re-test scores of Preliminary Study children and the age-unadjusted scores of the Main Study children do not show a hearing-status differentiation. The other scores of the 80 children show a statistically significant difference, the hearing children having a superior ability to sequence events, sizes, and shapes -- a superiority substantiated by the fewer and 'better' errors of the Main Study hearing children.

Two of the questions posed at the end of Chapter 2 have been answered: The types of errors the children made do show

cognitive progressions, and the scores of a larger sample of children are similar to the scores of the earlier smaller sample. Insights from the two studies are as one.

CHAPTER 4

HANDEDNESS RATIOS

They're all the same, just different.

An Irishman

In the previous chapter only the categorical handedness of the Main Study children was discussed. In this chapter their handedness ratios are reported, first the Inventory Handedness Ratios, then the Task Handedness Ratios. Ways in which the children are the same and different are described.

INVENTORY HANDEDNESS RATIOS (IHRs)¹

The success of the left-handed children in the Main Study, and of the Preliminary Study children who used their left hands to a greater extent when performing the sequencing tasks, is seen also in the children's handedness preferences when doing the Inventory activities. The trend in the negative correlation of the children's IHRs with their age-adjusted scores ($r_s = -.196$, $p < .1$) is differentiated significantly for those who have IHRs that are left of the mean and high scores versus for those who have IHRs that are right of the mean and low scores (M-W $U=294$, one-tailed $p < .05$).

Because in previous results there was also an association of lower scores with mixed handedness, a group of children with right-of-mean but not extreme right IHRs was identified. Grouped by their IHRs into three handedness bands, children with leftward ratios are within Band 1; those with middle-right ratios are within Band 2; and those with extreme right ratios are within Band 3. The division between Bands 2 and 3 is where a break occurred in the ratio distributions.

¹For a complete description of the activities indicating the children's hand (and foot and eye) preferences, see the Handedness-Sidedness Inventory (Appendix H).

Between Bands 1 and 2, the division was determined by two approximations: to have it be near the mean ratio (as the mean ratio had divided the children in the Preliminary Study) and to have these groups as numerically balanced as possible. This placed the three children whose ratios are contiguous with the mean within Band 1. (At .429, their IHRs are .005 to the right of the .424 mean for all the children). In addition, the Task Handedness Ratios of two of them are left of the THR mean, in agreement with this leftward placement.

The hearing-deaf distributions within each band are similar: The deaf children, 33% of the children in the study, have a 35%, 31%, and 36% representation respectively within Bands 1 to 3.

Of the Main Study children, those who used their left hands to a greater extent when doing the Inventory activities (those with Band 1 IHRs) have the significantly highest scores. Some of the children with more mixed handedness (Band 2 IHRs) are superior, but collectively again these children have the significantly lowest scores, and the lowest incidence of a 'left factor'. Concomitant with the low scores of the deaf children within Band 2, there is a paucity of first-born children, a majority of older children, an absence of oral deaf children, and the exclusive inclusion of children with a 'high-risk' aetiology. The children who have extreme right (Band 3) IHRs have intermediate scores, the older hearing children their only higher representation.

The scores unbiased by age (the ASDs) of the hearing and the deaf children within each of the bands are summarized in Table 4.1.

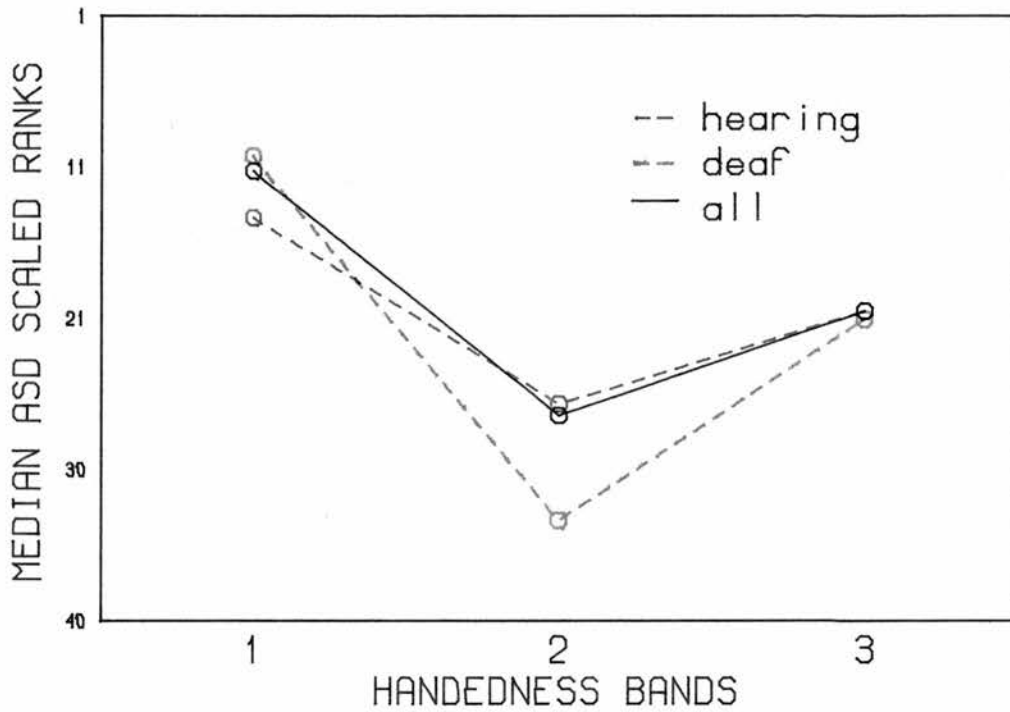
Table 4.1: HANDEDNESS BANDS BY SCORES
OF THE MAIN STUDY CHILDREN

	ASDs	
	mean	median
<u>Band 1</u> (n=23):		
Leftward ratios		
(IHRs at -1 to .429)		
Hearing children (n=15)	9.9	12.0
Deaf children (n=8)	-1.2	-1.0
	<hr/> 6.0	<hr/> 11.0
<u>Band 2</u> (n=26):		
Middle-right ratios		
(IHRs at .467 to .692)		
Hearing children (n=18)	1.9	.5
Deaf children (n=8)	-20.1	-19.5
	<hr/> -4.9	<hr/> -3.3
<u>Band 3</u> (n=11):		
Extreme-right ratios		
(IHRs at .818 to 1)		
Hearing children (n=7)	3.4	6.0
Deaf children (n=4)	-9.1	-10.8
	<hr/> -1.1	<hr/> 1.0

Totals:		
Hearing children (n=40)	5.2	5.3
Deaf children (n=20)	-10.4	-10.8
	<hr/> .0	<hr/> .0

The scores of the children with more mixed handedness, those within Band 2, differ significantly from the scores of the other children (M-W $U=316.0$, $p<.05$, for the ASDs of the Band 2 children versus of the combined Bands 1 and 3 children) and, selectively, from the children in Band 1, who used their left hands to a greater extent in the Inventory activities (M-W $U=201.5$, $p<.05$, for the Band 2 versus Band 1 children). By hearing status, the difference is significant only for the deaf children (M-W $U=17.5$, $p<.01$, for Band 2 versus all the other deaf children; M-W $U=10$, $p<.02$, for Band 2 versus Band 1 deaf children).

Figure 4.1: RANKS BY IHR BANDS



The greater variance among the deaf children is illustrated in Figure 4.1, which graphs the median ASD ranks in each handedness band for the hearing and the deaf children separately and together. (The ranks of the 20 deaf children are doubled to scale them to the ranks of the 40 hearing children.) The numbers of children with top ranks (1 to 20) and bottom ranks (21 to 40) within each band accentuate the superiority of the Band 1 children and the inferiority of the Band 2 children. Note in Table 4.2 how the differences among both the hearing and the deaf children are parallel, yet how the Bands 1 and 2 reversals are amplified among the deaf children -- their differences being three-fold, the hearing children's differences two-fold.

Table 4.2: HANDEDNESS BANDS BY SCORE RANKS

	Band 1		Band 2		Band 3	
	+m	-m	+m	-m	+m	-m
Number of hearing children	10	5	6	12	4	3
deaf children	6	2	2	6	2	2
	<u>16</u>	<u>7</u>	<u>8</u>	<u>18</u>	<u>6</u>	<u>5</u>

+m = above mean (ranks of 1-20)

-m = below mean (ranks of 21-40)

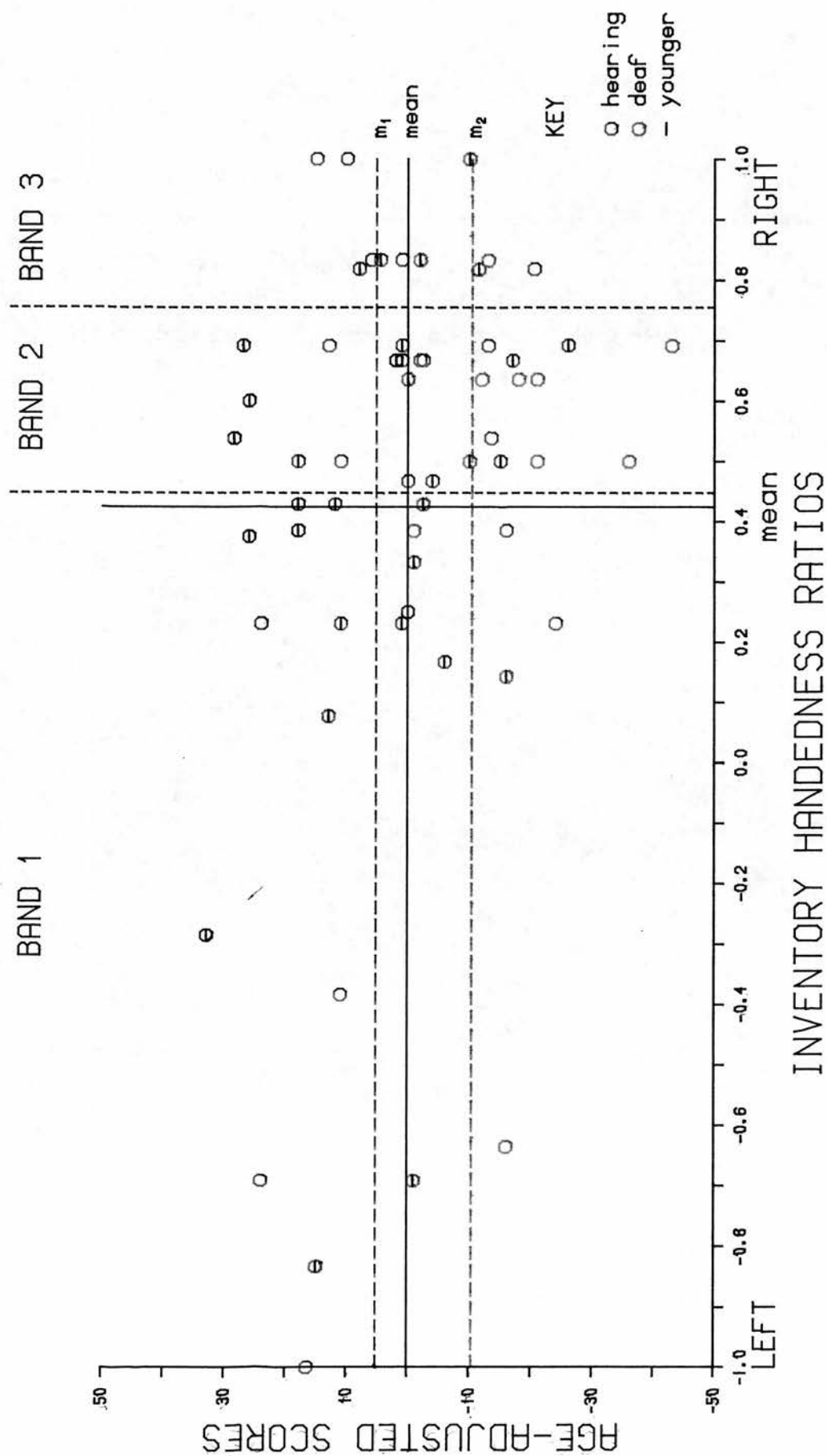
Chi-square significance for all the children:

Band 1 versus Band 2 versus Band 3	$p < .05$
Band 1 versus Bands 2 and 3	$p < .05$
Band 1 versus Band 2	$p < .02$
Bands 1 and 3 versus Band 2	$p < .02$

The following descriptions of the children within the three handedness bands refer to their score distributions (Figure 4.2a).

Band 1. The 23 children with the most leftward IHRs include all the categorically left-handed and ambidextrous children, half the first-born children, the three children who have perfect scores, and the two deaf children whose ASDs are above the mean for all the children. Only three (20%) of the 15 hearing children in Band 1 have ASDs below the mean for all the children. (The two of them who are girls are also the only left-handed/ambidextrous children who have left-of-mean but not negative IHRs, at .231 and .167.)

Figure 4.2a: SCORES BY IHRs



Band 2. Of the 26 children whose IHRs are concentrated within Band 2 (those with right-of-mean but not extreme right IHRs), most have exceptionally low scores. A few, however, have exceptionally high scores. They are the four hearing children whose scores are the highest within Band 2, and among the eight highest of all the children. All four are younger than the hearing mean, by an average of three months; they comprise 36% of the younger hearing children within Band 2 but 67% of the hearing children within this band whose scores are above the hearing mean (m_1 in Figure 4.2a).² The ASDs of these four exceptional hearing children average 25, which is 30 points above the Band 2 mean and 13 points above the other two top hearing scorers in Band 2. Their high ASDs reflect their high total scores: They are four of the five younger hearing children whose total scores as well as ASDs are above the means.³

Furthering the girl-with-a-curl suggestion that when these children with more mixed handedness are good, they are very, very good are the five hearing above-mean scorers whose handedness ratios are outside but adjacent to Band 2 (IHRs of .375 to .429 and .818): They all are also in the younger hearing age group.

And when they are bad... A characteristic of four of the five lowest scorers within Band 2 -- including the three lowest scorers of all the children -- is the absence of a familial 'left factor'. Among all the Band 2 children, the incidence, and more positive influence, of having a left factor is the lowest (54%) -- lower than for the Band 1 children (70%) but

²Both deaf children in Band 2 whose scores are above the deaf mean (m_2 in Figure 4.2a) also are in the younger deaf age group -- but so are all but one of the other deaf children who have higher scores. However, that there are only these two younger deaf children within Band 2 presents a reverse preponderance: 75% of the deaf children in both Bands 1 and 3 are younger than the deaf mean, but 75% of the deaf children within Band 2 are older.

³The other younger hearing child and the only younger deaf child with both scores high are in Band 1.

also lower than for the Band 3 children (64%). This pattern of more mixed handedness ratios associated with low scores and the absence of a left factor corroborates results of the Preliminary Study, in which three of the four children with only right-handedness reported for them and others in their families are within the middle handedness range (their ratios within .074 of each other), and they are three of the four lowest scorers in that study.

Other low incidences in Band 2 concern the deaf children. One is in contrast to the 50% representation of first-born deaf children in each of the other bands: Only one (13%) of the eight deaf children in Band 2 is a first-born child -- and he is the highest deaf scorer in Band 2.

An absolute absence in Band 2 is of the oral deaf children. While in the other bands there are equal numbers of oral and total communication children (four each in Band 1 and two each in Band 3), within Band 2 all eight are TC children. This could be an example of Phippard's (1977) finding: no asymmetry among sign-language-oriented subjects but lateralized functioning among oral deaf subjects.

Another absolute incidence in Band 2 is related to aetiology. All three children whose deafness was caused by perinatal insult are within Band 2. (The two of them without a left factor are the lowest scorers in the study.) It is thought that children with this nongenetic aetiology are 'neurologically at risk' and that they differ from genetically deaf children by having less compensatory right-hemisphere reorganization (Wolff and Thatcher 1990, referred to again in Chapter 9). Therefore, not only deafness in general but also signing and a nongenetic aetiology in particular are associated with decreased hemispheric specialization -- and with mixed handedness and the significantly lowest sequencing task scores.

A question to consider is whether signing might be a compounding risk factor. As the sets of felt shapes with more

multiple attributes, hence choices, are associated with lower scores, perhaps the multiple communication input could contribute -- for some children -- to their lower scores, or at least detract from their being higher.⁴ A fact to reiterate is the consensus of studies concluding superior achievements, measured scholastically and socially, of TC deaf children over oral deaf children, and their parity in this study -- even though all the children whose aetiology is birth injury are in TC programmes. When the calculations do not include the three 'high-risk' deaf children, there remains a trend in the differences between the scores of the children in the three bands (e.g. M-W $U=200.5$, $p>.1$, between Band 1 and Band 2 scores -- the U value actually lower than with these children not excluded). It would seem that aetiology is but one important factor.

Children in the Preliminary Study are similar: a) The one child in that study who has a high-risk aetiology (meningitis) also has a rightward handedness ratio. (At .305, it is right of the overall mean of .079 and the deaf mean of .239.) b) The only two outlying handedness ratios (of -.410 and .767) of the deaf children in the Preliminary Study are those of right-handed children in the oral programme.

Although all together 30 deaf children were tested in the Preliminary and Main Studies, numbers within subgroups by aetiology and educational programme are too small for an independent conclusion. The findings, however, are sufficiently consistent with other studies for there to be further investigation into the effects of specific aetiologies and the communication methods of individual children.

⁴On the shape continuation task, the one child with an aetiology of insult at birth (prematurity -- delivery with forceps at 28 weeks and birth weight of 1.38 kilograms) and a left factor (two left-handed paternal relatives) scored 100%. However, the other two children with this aetiology and no left factor, and the lowest scores, scored their lowest (22%) on this task.

Band 3. The 11 children with extreme right IHRs are not extreme in some other ways. As shown in the previous tables and graphs, their scores are in between the highest in Band 1 and the lowest in Band 2; they are within the narrowest range (+15 to -20.5), and they are evenly distributed above and below the hearing and the deaf means. Another balance/cancellation is of the two hearing children in Band 3 who have twin sisters: One scored above, the other below, the hearing mean.⁵

In age, though, there is a difference in Band 3: While older deaf children are in the majority only in Band 2, it is in Band 3 that there is the only majority (71%) of older hearing children.

TASK HANDEDNESS RATIOS (THRs)

From the most general measure of the children's manual lateralities (their categorical handedness) to the groupings by scaled preferences (the IHR bands), the ratios to be discussed next provide the most specific information. The THRs indicate the particular ways the children in the studies used their hands when doing the sequencing tasks. Analyses of each of the contact categories on each of the tasks may show what methods are most associated with task success or failure. As for the 20 Preliminary Study children, it is the *frequency* counts of the contacts of the 60 Main Study children that are reported in this chapter. Analyses of the interrelationships between the different types of contact and the scores of each child are reported in Chapter 5, information about the

⁵The twins of these Band 3 girls are in Bands 1 and 2. Both pairs of twins showed interesting mirror sidedness preferences: The one who is ambidextrous wrote her name and began her drawing with her left hand and preferred to hop on her left foot, the opposite of her right-handed sister. Of the other pair, the higher scorer clapped with her right hand up, clasped her hands with her left thumb up, wound string with her left hand, was successful only with her left hand when simultaneously spinning two tops, hopped on her left foot, and sighted with her left eye; lateralities of her twin were the reverse for each action.

duration of contacts and other handedness patterns of samples of children in Chapter 6, and individual children are described in Appendix G.

To account for all contacts with the materials, an Assist (A) category was added to the Placement (P) and Collection (C) categories. 'A' counts are of preparatory and intermediate hand-to-object contacts, such as removals of materials from the envelopes, separation distributions, holdings, and transfers of objects from one hand to the other. Also to obtain complete information, counts were made of the Task A as well as Tasks B and C contacts, and were included in calculating the THRs of the Main Study children -- the means of the Placement and Collection ratios on Tasks A-C. Only the P and C contacts were used because they were considered more deliberate acts than Assists, they have the highest consistent inter- and intra-task correlations (see Tables 4.3 and 4.4), and they allow more accurate comparisons with the THRs of the Preliminary Study children (also computed from the P and C means). With and without the A contacts, the ratios are very similar ($r_s=0.94$ to 0.98 , $p<.001$, for the three tasks separately and together).

Inter-rater reliability counts for the Main Study children, as for the Preliminary Study children, were of the P and C contacts on Tasks B and C. The handedness ratios of 12 children (six hearing and six deaf children, comprising 20% of the study population) obtained independently by the researcher and another rater are, again, highly consistent ($r_s=0.99$, $p<.001$).

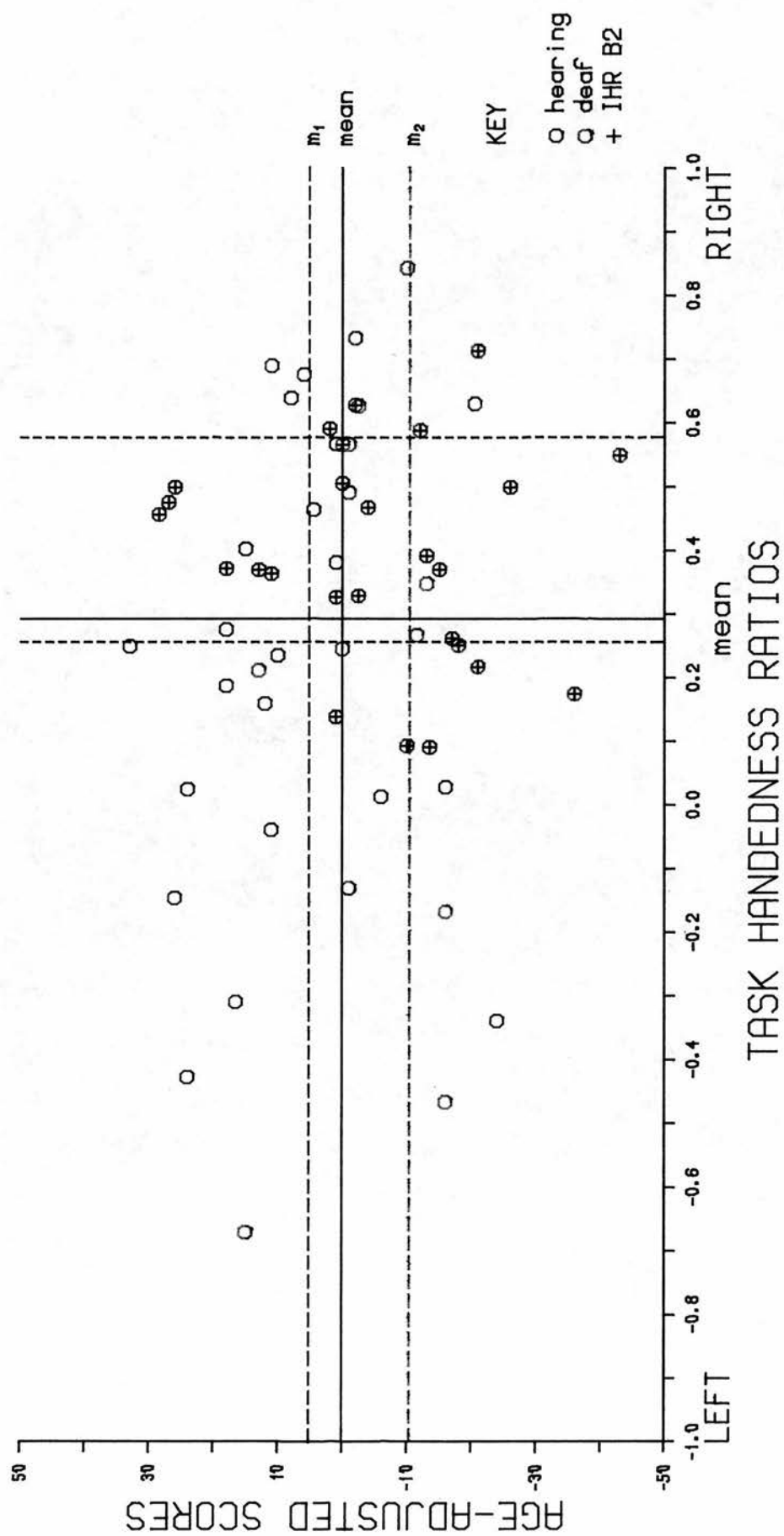
THR-IHR Comparisons

The Task Handedness Ratios of the children correlate significantly with their Inventory Handedness Ratios ($r_s=0.60$, $p<.001$). For most (83%) of the left- and right-handed children, their IHRs are consistently the more extreme, in the direction of the children's categorical handedness. The two ambidextrous children vary: The one who is the highest scorer

has a more leftward IHR than THR; the other, with a low score, has a more rightward IHR (as has one left-handed child, the lowest-scoring left-hander). One child is an exception because her THR and IHR are identical. Of the other exceptions, the nine children whose task rather than Inventory handedness is the more lateralized, there is a higher representation among the deaf than the hearing children (25% versus 10%), and a highest representation among the Band 1 children (33%, versus 8% in Band 2 and 0% in Band 3).

Compared with the IHRs, the THRs of the children are more concentrated, within a more constricted range ($-.673$ to $.843$ for the THRs, versus -1 to 1 for the IHRs), and so are less amenable to handedness band groupings. When artificial divisions are made between leftward, middle-right, and furthest-right THRs, to create groups corresponding numerically to the IHR Bands 1-3 (the THR:IHR numbers respectively 24:23, 25:26, and 11:11), results reported for the children within the critical IHR Bands 1 and 2 are unaltered. All the left-handed/ambidextrous children (collectively the higher scorers) and the other highest scoring deaf child are still within the left-most group. Sixteen children (61%) remain in the middle, more mixed-handedness, THR group. (See the IHR Band 2 distributions in Figure 4.2b.) They include the six hearing children in Band 2 who scored above the hearing mean, the highest deaf scorer in Band 2, and the overall two lowest-scoring hearing and deaf children. Of the six oral deaf children, two are included in the middle-range THR group, but marginally: Their THRs are less than $.020$ and $.002$ from the contiguous leftward and further-right ratios.

Figure 4.2b: SCORES BY THRS



While the THRs, like the IHRs, correspond to the children's categorical handedness, of the three measures of handedness, it is the THRs that show the greatest bilaterality. Eighty-five per cent of the children were considered right-handed, and both ratio means are biased rightward: at .424 for the IHRs, with 67% of the children to the right; at .292 for the THRs, with 55% of the children to the right. (The THR mean for the 51 right-handers is .385, for the two ambidextrals .131, and for the seven left-handers -.342. All the left-handers and two right-handers have negative THRs; both ambidextrals and 16 right-handers have left-of-mean THRs.) Therefore, although 15% of the children are categorized as left-handed/ambidextrous, 45% of the children have left-of-mean THRs; i.e., they used their left hands dominantly or both hands with approximate equivalence when doing the sequencing tasks.

Handedness Ratios on Tasks A-C

For each of the 60 children in the study, 33 ratios were obtained: one for each of the three contact categories on each of the sets within each task.⁶

Task A: 6 sets x 3 contact categories = 18 ratios
 Task B: 2 sets x 3 contact categories = 6 ratios
 Task C: 3 sets x 3 contact categories = 9 ratios

The handedness ratios reported in this section are the means of the Placement and Collection ratios on each of the three tasks -- those used to calculate the THRs. (The Assist ratios, so specified, are reported separately.)

Thirty-six children (60%) have positive mean ratios on all three tasks; their right hand was consistently dominant. They

⁶Ratios were also calculated on sets 7 and 8 of Task A for the children who completed either or both of these sets, but only the first six sets completed by all the children were used in the analyses. For reference, all the children's individual ratios, and scores, are listed in Appendix B.1.

were all classified as right-handed. With twelve of them deaf and twenty-four hearing, this proportion is the same as in the total population.

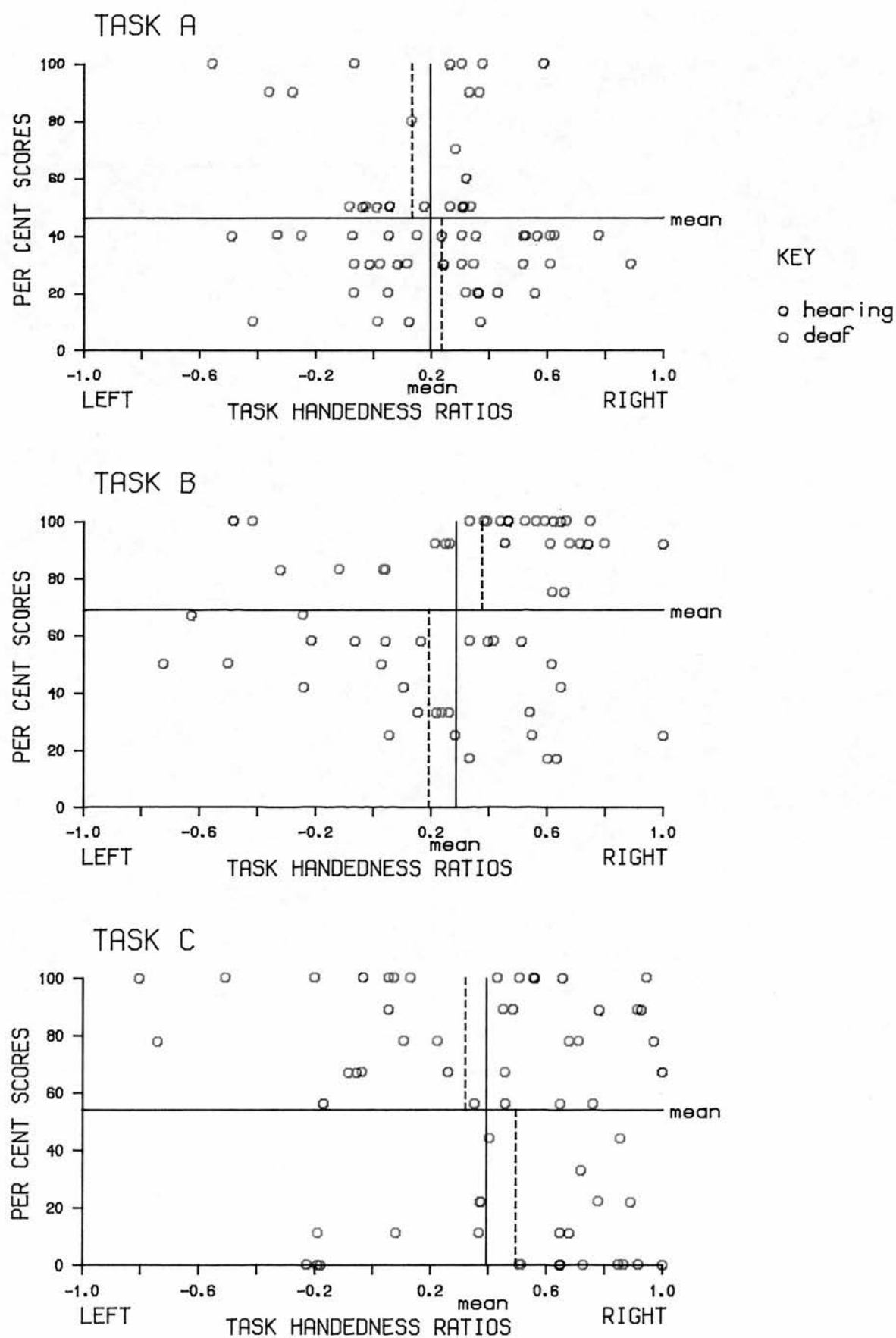
Of the 24 children who have a negative mean ratio on at least one task, nine are the left-handed/ambidextrous children; the other 15 were classified as right-handed, i.e. 29% of the right-handed children. (Those who have a negative mean ratio on only one task are both ambidextrals and 12 right-handed children; on two tasks, they are two left-handers and two right-handers; and on all three tasks, they are the other five left-handers and one right-hander, an oral deaf girl.)

Tasks A-C ratios and scores. While the ASDs (the scores calculated from the mean score of the three tasks together and adjusted for age) provide general information, unbiased by the age differences of the hearing and the deaf children, the per cent scores can provide specific information, unbiased by hearing status, about the children's absolute performance on each task and how this relates to the handedness ratios for each task. Thus, unless otherwise indicated, 'scores' in the following table and in the graphs and analyses refer to the children's per cent scores.

Table 4.3: CORRELATIONS OF HANDEDNESS RATIOS
AND SCORES ON TASKS A-C

	Handedness Ratios		Scores	
	r_s	p	r_s	p
Task A with Task C	0.277	<.020	0.287	<.020
Task A with Task B	0.404	<.002	0.339	<.005
Task B with Task C	0.690	<.001	0.445	<.001

Figure 4.3: RATIOS BY SCORES ON TASKS A-C



The lowest inter-task correlations (shown in Table 4.3) and the lowest score and ratio means (shown in Figure 4.3) are on Task A.⁷ On the whole, the children's hand-to-object contacts were the most bimanual and symmetrical when they were handling the picture sequencing cards (Task A, ratio $m=.196$); their contacts were more lateralized with the different-sized clown and dog cutouts (Task B, ratio $m=.286$) and, especially, with the felt shapes (Task C, ratio $m=.393$). Also, Task A ratios (and scores) tend to cluster close to the mean(s), while the ratios for Tasks B and C are more diffuse.

The handedness differences on the three tasks relate conspicuously to board space and numbers of objects manipulated. The further away objects were placed and the more objects there were in the sets, the more lateralized the movements were. The progression is from the fewest materials that occupy the least space in the least lateralized task (A) to the most materials that occupy the most space (the length of the board) in the most lateralized task (C). Also within Task A this difference is seen: The handedness ratios of two-thirds of the children are nearer zero with the two-card than with the three-card sequences.

The differences also relate to task difficulty. The lowest mean score on Task A contrasts to the higher mean scores on Tasks B and C; also, the fewest children scored above the mean

⁷Although some dots on the graphs are obscured by the axis lines and overlays, exact numbers for the groups discussed are given in the text.

on Task A (23, versus 31 on Task B and 36 on Task C).⁸ The degree of difficulty/cognitive complexity, possibly with a commensurate degree of bi-hemispheric involvement, is thought to be greatest for Task A (discriminating and relating details in temporal and spatial dimensions), less for Task B (judging comparative sizes), and least for Task C (repeating shape patterns). This progression is exactly represented in the shifts in the direction and concentrations of the ratios, from Task A to Task B to Task C. Furthermore, because Task A theoretically requires the greatest amount of bi-hemispheric thinking and because this task might predispose (by the more confined, central space for operations) -- and shows -- the greatest amount of bimanual movement, this combination could pose a conflict, causing or contributing to the lowest scores on that task.

Task B and Task C comparisons. Details of the direction and degree of manual laterality on the two tasks with the more diffuse handedness ratios were analyzed and compared. These tasks are of special interest regarding hearing status: Task B is the one task on which the scores of the deaf children are significantly lower than the scores of the hearing children. On Task C, the deaf children's scores most approximate the scores of the hearing children.

Task B, size progressions: The most prominent Task B group (as shown in Figure 4.3) is that of the above-mean scorers who

⁸As reported in Chapter 1, Gesell and Ames (1947) considered task difficulty to be a potential determinant of hand use. Their observation that "bilateral behaviour seems to occur only when the situation is very difficult" (p. 166) was about children when they were about five years old, i.e. within nine months of the mean age of the Main Study children. Their addition "or involves several objects simultaneously" applies generally to the spontaneous actions of the children in the thesis studies (see Chapter 6 and the Discussion in Appendix H) -- regardless of the total number of objects in a set. The more critical quantitative factor regarding simultaneity at this age/stage might be not the greatest number of objects to be manipulated but, rather, the greatest opportunity for simultaneous movements when operating within a narrower, central space, as in Task A. And the critical qualitative factor could relate to the complexity and kinds of different mental processes involved and different attentional states (see above).

have right-of-mean handedness ratios. They constitute 68% of the above-mean scorers and 64% of those with rightward ratios. Among them are 12 (80%) of the 15 perfect scorers and four (again 80%) of the five deaf children who have above-mean scores.

However, the other three perfect scorers, who have left-of-mean -- and left-of-zero -- handedness ratios, are remarkable: In addition to their perfect scores on Task B, all three have above-mean total scores and above-mean ASDs, versus 42% of the other Task B perfect scorers.⁹ Their excellence, of having the age-adjusted score as well as the total per cent score above the means, extends to the entire group of above-mean scorers on Task B whose handedness ratios are left of the mean: 70% of them versus 38% of the group with ratios to the right of the handedness mean also have both high total scores and high ASDs. Even among the lower scorers on Task B, four of the seven (57%) with negative (left-of-zero) handedness ratios have above-mean ASDs (one also an above-mean total score), versus four of the 22 (18%) with positive (right-of-zero) ratios (of whom none have a high total score).

When considering handedness in these absolute terms -- counting those with ratios either to the left or to the right of zero, other differences can be noted: 1) Among the perfect scorers on Task B, there is a considerable gap, of .751, between the left and the right ratios. 2) Among the children with the three very lowest scores and all 12 with scores in the lowest quartile (between 17% and 33%), there is a conspicuous absence and presence: None of these children have negative ratios, and the ratios of the hearing children are concentrated within a middle range (from .056 to .550). (The furthest-right ratios within this lowest-scoring group, those

⁹Other comparisons are that all three are girls, versus half of the other perfect scorers; age-wise, they average one-half year younger; and, while two are left-handed, the one with the left-most ratio, of -.483, is right-handed. (She is Polly, one of the exemplars described in Appendix G.)

of deaf children, are discussed below.)

There is therefore, again, a suggestion that children who use *either* their right or their left hand with greater frequency -- rather than *both* hands with more equal frequency -- are those whose scores are superior. Such a differentiation could be especially advantageous on this task, which would seem to require more left-hemispheric thinking for the ordering of objects by relative size. (The 'than' in this comparison could be about the hemispheres *and* the tasks: regarding left hemisphere functioning particularly on Task B versus right hemisphere functioning on Task C, and both hemispheres functioning collaboratively on Task A.)

The children whose handedness is the most lateralized on Task B are deaf. Six of the eight most rightward ratios of all the below-mean scorers (including the three most rightward ratios of the lowest-quartile scorers) belong to deaf children. With divisions between above- and below-mean scores and between negative and positive ratios, it is on Task B that the deaf children have the largest representation in the lower right quadrant (those with ratios right of zero and lower scores): Eleven deaf children constitute 50% of this group (with corresponding percentages of 41 and 40, respectively, on Tasks A and C). The other four deaf children who have Task B ratios right of zero but who have *above-mean* scores constitute only 15% of that numerically prominent group. (When the relative handedness *mean* is used, the corresponding figures for Task B are 58% and 19% -- a difference of 39%, which is much greater than the 11.5% difference on Task C, and 17% on Task A.) Thus, what seems to be right for the children in general -- to use their right hands predominantly when arranging the cutouts by size -- seems to be less right for the deaf children, and might partly explain the significantly lower scores of the deaf children on this task.

Of all the Task B ratios, the two that are furthest to the left and the two that are furthest to the right (at +1) are those of four deaf boys. By mode of communication, these deaf

children illustrate the general pattern reported about the IHR handedness bands: Three of them are in the oral class. Actually, of the six deaf children whose ratios are the most leftward, four are in the oral class. Two of these children are *right-handed* (one with a ratio further to the left than that of a hearing left-hander), and the two who are left-handed have further-left ratios than the other five left-handed children (including the one left-hander who is in a total communication class, and who is the only deaf left-hander with an above-mean score on Task B). Thus, most of the deaf children who communicate orally (five of the six -- all but the youngest) have especially lateralized hand movements on this task, whereas the deaf children who use both hands to communicate also used both hands to a greater extent in doing this task. Neither group excelled: Versus 65% of the hearing children, 25% of the deaf children scored above the mean on Task B. Of the five deaf above-mean scorers, one (who has a +1 ratio) is in the oral class. Therefore, 17% of the oral deaf children and 29% of the total communication deaf children have above-mean scores on this task.

Task C, the pattern continuations: In contrast to the right-of-mean handedness ratios for most of the higher and perfect scorers on Task B, on Task C, there are nearly equal numbers of above-mean and perfect scorers who have left-of-mean and right-of-mean ratios: 20 leftward and 19 rightward among the above-mean scorers, seven and six, respectively, among the perfect scorers.¹⁰ The symmetrical handedness distribution of the higher and highest scorers on Task C also contrasts to the asymmetrical distribution of lower scorers on this task. Again most of the lowest scorers, but also most of all the lower scorers, have rightward

¹⁰On Task C the handedness ratio mean is more rightward (.393 versus .286 on Task B) and the range of the ratios is slightly greater (from -.805 to 1 versus from -.724 to 1 on Task B). Note also that on Task C, as on Task A, the handedness mean of the higher scorers is more leftward, the mean of the lower scorers more rightward.

handedness ratios: Nine of the 12 children (75%) who scored zero on Task C have ratios that are right of the mean -- in fact, right of zero. Of all the below-mean scorers, 83% have positive ratios; 67% have right-of-mean ratios -- almost exactly the same proportion (68%) for the right-of-mean *higher* scorers on Task B.¹¹

Absent in Task C is the spate of middle-range but below-mean scorers with leftward handedness ratios that is shown in Task B. (Task C presents a downward complement: While the lowest below-mean score left of the handedness mean on Task B is 25%, the *highest* score of this quadrant on Task C is 22%.) However, on Task C, as well as on Task B, the children with left-of-mean ratios excel: Twice as many of them scored above than below the mean (17 versus eight), contrasting to the more even distribution of the children with right-of-mean ratios, of whom 19 scored above and 16 below the mean.

Among all the higher scorers, there are important representational differences on the two tasks. While overall five more children scored above the mean on Task C, it is among the left-handed/ambidextrous and deaf children that the differences appear. On Task B five, but on Task C eight (all but one), of the left-handed/ambidextrous children scored above the mean; three have perfect scores on Task B, four on Task C (a 56% representation, versus 16% for the right-handers). Of the deaf children, five scored above the mean on Task B, two with perfect scores, but on Task C ten scored above the mean, three with perfect scores.

The greater numbers of the left-handed/ambidextrous children and the deaf children among the higher scorers on Task C versus on Task B, and the reversal in the children who have

¹¹Of the five deaf children who scored zero on Task C, three are in the oral class (representing 50% of the oral children versus 14% of the total communication children). The other children in the oral class (three boys) have above-mean scores and again have extreme handedness ratios -- the two most leftward and the second most rightward of all the children.

rightward handedness ratios -- of top scorers on Task B and bottom scorers on Task C, suggest it was not merely the greater board space occupied by the felt shapes that affected the handedness differences. The nature of the tasks would also have affected hand use. One difference between the tasks is the presumably greater, more exclusively right-hemispheric visual-spatial component in the shape pattern continuations of Task C. (A related, perhaps not trivial, difference is the visual configuration of the arrays: The rather balanced appearance of the shape pattern repetitions contrasts to the asymmetrical pattern of the size progressions in Task B.)

Last to consider in this chapter are specifics of each of the contact categories.

Placement, Assist, and Collection Distributions

In the matrix below (Table 4.4), the particular highest correlations on Tasks B and C are shown along with the correlations of each contact category.

Table 4.4: CORRELATIONS OF THE THREE CONTACT CATEGORIES WITHIN AND BETWEEN THE THREE TASKS

	Task A			Task B			Task C		
	A	C	P	A	C	P	A	C	
Task A									
P	.445***	.240*	.423***	.256*	.254*	.440***	.181	.161	
A		.419***	.274*	.507***	.197	.400**	.344**	.298*	
C			.169	.313**	.376**	.322**	.170	.171	
Task B									
P				.528***	.236*	.407**	.273*	.364**	
A					.344**	.516***	.549***	.552***	
C						.369**	.339**	.654***	
Task C									
P							.613***	.415***	
A								.458***	

P: Placements
A: Assists
C: Collections

Bold type: Correlations of same contact categories

* r_s , $p < .05$
** r_s , $p < .01$
*** r_s , $p < .001$

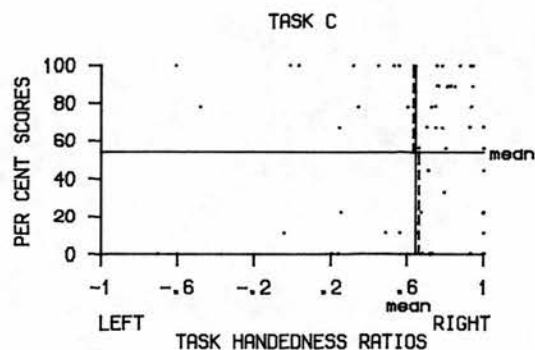
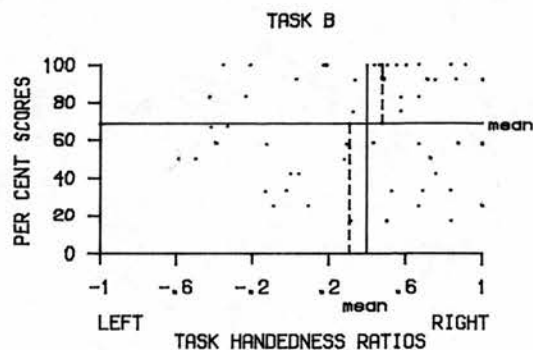
The three contact categories are alike in their highly significant inter-task correlations (with the three-task mean r_s from 0.400 for Collections to 0.467 for Assists, $p < .001$). Yet there are distinctions between the three kinds of contact:

On each task the least similar contacts (those having the lowest correlations) are the Placements and Collections, and the Assists correlate higher with the Placement than with the Collection contacts. (The possibility that a child's dominant hand in placing the objects is also his dominant hand in the assisting movements, and that his other hand is more involved in collecting the materials, led to analyses of each child's ratio combinations, reported in Chapter 5. In this section, general patterns for each contact category are discussed.)

Looking at Figure 4.4, we can see the greatest amount of symmetry, that is, the most equivalent frequency of left-hand and right-hand use, in the Assist contacts. On both Tasks B and C, the Assist contacts have the lowest mean (.066 on Task B and .111 on Task C) and the greatest concentration around the mean. The next most bimanual are the Collection contacts (with the Task B mean of .177 again similar to the Task C mean of .141). Placement contacts are the most lateralized: The further rightward mean is .396 on Task B and a radical .645 on Task C. Following Darwin's principles first of observing before theorizing and second of accepting the simplest explanation (Charlesworth and Kreutzer 1973, Petrinovitch 1973), we would hypothesize a hierarchical relationship of (assumed) mental deliberation and (shown) handedness differentiation -- both the greatest for Placements, then Collections, and least for Assists. The hand movements of the children are reported in this order.

Figure 4.4: SCORES/RATIOS FOR CONTACT CATEGORIES

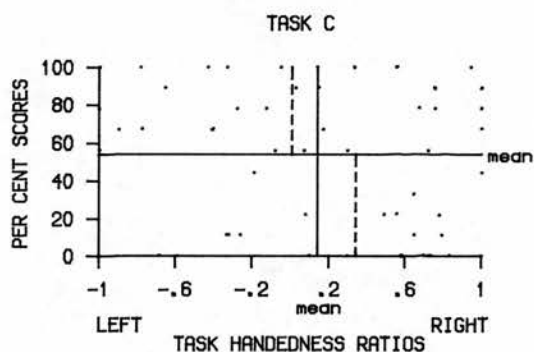
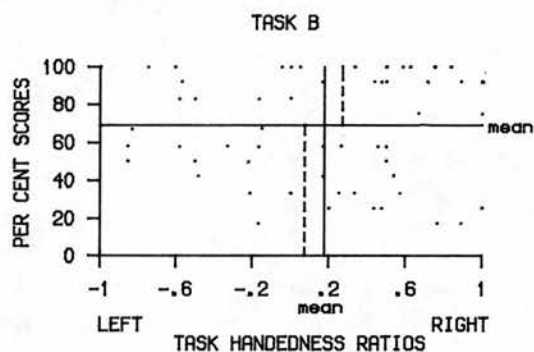
PLACEMENTS



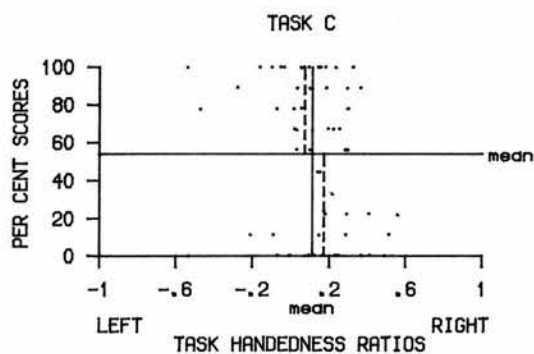
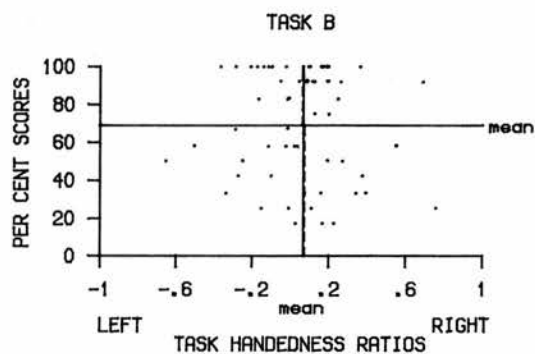
KEY

- hearing
- deaf

COLLECTIONS



ASSISTS



Placements. The Placements of the shapes (Task C) are exceptional in two respects. First, not only is the ratio mean the furthest to the right, but also the proportion of children right of the mean is the greatest: 41 children (68%) have right-of-mean ratios, and constitute nearly equal proportions of the above- and below-mean scorers (67% and 71%, respectively). The numbers of left-of-mean and right-of-mean perfect scorers (seven and six, respectively) present an ostensible parity. However, because of the inequality of the ratio distribution, relative to total numbers, perfect scorers comprise 37% of the children with left-of-mean ratios, more than twice the 15% representation of the right-of-mean perfect scorers. The 12 zero scorers show a more comparable proportion, although still a left advantage: Three (16%) are left of the mean; nine (22%) are right of the mean.

Secondly, another group of 12 children is remarkable because they placed all 27 shapes exclusively with their right hands. Of them, nine (75%) scored below the mean, five at zero. (They include two children who are included in other reports: Jimmy, the deaf child with the lowest ASD, and Lucy, whose ASD is the lowest, her total per cent score the second lowest, of the hearing children.)

Placing the clowns and dogs in order by size (Task B), the children showed the next most rightward bias, again both in the ratio mean and numbers, with 36 children (60%) having ratios right of the mean. The Task B Placements of the below-mean scorers are equivalent -- *and identical to the Task B Assists and Collections*: 15 are left of the mean and 14 are right of the mean. However, of the 31 above-mean scorers, 22 (71%) have right-of-mean ratios. The rightward concentration of the Placement ratios of the 15 higher scorers who have perfect scores contrasts to the more equivalent leftward and rightward distribution of their Assist ratios on this task: 11 (73%) are right of the Placement mean, but only seven (47%) are right of the Assist mean. (This comparison is included in Table 4.5, at the end of the *contacts* report.) Note the consistency in the separate ratio means for the above- and

below-mean scorers (again shown by the dotted lines in the graphs): On Task B the mean handedness of the higher scorers is more rightward for Placements and Collections, whereas for both these actions (and the Assists) on Task C, theirs are more leftward.

Collections. Compared with the Placement ratios, the Collection ratios show a more even distribution, a more equal frequency, of left-hand and right-hand use among all the children. Collection means are only slightly more rightward than the Assist means: by .111 on Task B (versus the Placement-Assist difference of .330 on Task B) and by only .03 on Task C (versus .534 between the Placements and Assists on Task C).

It is mostly the above-mean scorers who account for the greater numbers of left-of-mean ratios on Collections than on Placements (10% more on Task B and 22% more on Task C among the higher scorers, versus no difference on Task B and only a 4% increase on Task C among the lower scorers), and for more of the further-left Collection ratios, particularly on Task C.

On Task B, the furthest left Placement ratio of $-.590$ was surpassed on Collections by six children (with Collection ratios from $-.607$ to -1), half of whom have perfect scores. On Task C, the greatest leftward increase is shown in the hearing children's ratios -- 17 being further to the left on Collections than the most leftward hearing child's ratio for Placements.

Four children collected the cutouts of Task B exclusively with their right hands, one child exclusively with her left hand (thus having Collection ratios of $+1$ and -1 , respectively). All but one of these children scored above the mean, the child with the -1 ratio at 100%. Higher scores on Task B are associated more with exclusive right-hand Collections than Placements: Three of the four children (75%) who have $+1$ Collection ratios versus two of the five children (40%) who have $+1$ Placement ratios scored above the mean.

The five children who collected all the *shapes* with their left hands exemplify the association of more leftward ratios and higher scores. All have above-mean scores, three at 100%. Of them, two have a perfect score on Task B also, and the other three scored higher on this task, i.e. the task with their furthest left ratio. A similar number of children collected the shapes exclusively with their *right* hands -- six, of whom four (67%) have above-mean, but not perfect, scores. (Recall that 12 children, i.e. twice as many, *placed* all the shapes with their right hands, but that only three (25%) of them have above-mean scores.)

Four children (all boys, of whom three are deaf) used their right hands exclusively both to place and to collect all the cutouts of Task B or all the shapes of Task C. On each task, one scored above and one below the mean.

When considering the total number of children who have -1 and +1 Collection ratios (i.e. those whose Collections of the cutouts or the shapes were exclusively either left-handed or right-handed), we find that 80% (four of five children) on Task B and 82% (nine of 11 children) on Task C have above-mean scores. As no Placements were exclusively left-handed, the contrasting proportions of above-mean scorers with exclusive right-hand Placements are repeated: 40% on Task B and 25% on Task C. Therefore, rather than the general lack of advantage seen for exclusive one-handed (right-handed) Placements, exclusive one-handed (especially left-handed) *Collections* appear to be a distinct advantage.

Assists. The distribution of the Assist ratios is curiously

less symmetrical on Task C than on Task B.¹² The more leftward Assist mean of the above-mean scorers on Task C is almost identical to that of the above-mean scorers on Task B (differing by .008: at .062 on Task B and at .070 on Task C); the Assist mean of the below-mean scorers is .101 more rightward on Task C (at .171, versus .070 on Task B).

Also curious is the fact that the children whose handedness is the most lateralized for Assists are all deaf children. The two furthest left and the two furthest right Assist ratios on Task B belong to deaf children, three whose Task B Placement and Collection ratios also are at the extremes. The three outlying (left) Assist ratios on Task C are those of deaf children who also have the most leftward Placement ratios on that task. (The furthest right Assist ratio on Task C is that of the deaf child, Jimmy, who is the oldest child in the study, the one whose ASD is the lowest, and whose score on this task is his lowest.) Among the six deaf children who have outlying Assist ratios on either of these tasks (one child on both tasks), there is a difference regarding their mode of communication: Three are in the oral deaf programme. Thus, of the six oral deaf children in the Main Study, 50% have these most extreme ratios, in contrast to 21% of the deaf children who are in total communication programmes. By sex, there also is a difference: As all but one of these children are boys, that 83% representation is greater than the 65% majority of boys among the deaf children in the Main Study.

On Task B, more of the higher scorers have right-of-mean than

¹²A reason more similar frequencies for the use of each hand on Task C could have been expected is that the felt shapes tended to stick together. (A few children did use one hand, shaking off an unwanted shape, but most used both hands to separate them.) Nor does the smaller size of the Task C materials explain the difference, because the Assist ratios of the two Task B sets do not differ: Although the dogs are much smaller than the clowns, the Assist means of the two sets are almost identical (.052 for the clowns and .092 for the dogs), and the Assist movements are actually more lateralized, to the right and to the left, for most (63%) of the children when handling the smaller dogs.

left-of-mean Assist ratios: 18 (58%) are to the right, versus 13 to the left. (As mentioned previously, and as is shown in the following table, among the perfect scorers, there is a split, with eight to the left and seven to the right of the mean.) On Task C, there is another 58% distribution among the higher scorers, but for those (21 out of 36) who have left-of-mean ratios (and of whom the perfect scorers have a similar, but higher, 62% leftward majority).

There is, however, that marked skew on Task C. The Assist ratios of the lower scorers have a reverse, rightward, predominance: 17 (71%) are right of the mean, only 7 to the left. This Task C Assist distribution of the lower scorers is exactly the same as in their Task C Placements and is the same but for one child as in their Task C Collections (with 16 to the right and eight to the left of the mean). Since among the lower scorers on Task B the numbers of children to the left and to the right of the handedness mean are identical (15 and 14, respectively) for all three types of contact, it is clear that on both these tasks, handedness, relative to the laterality means, is differentiated by type of contact only by the higher, and highest, scorers.

Table 4.5 summarizes the leftward and rightward ratio distributions by type of contact for two numerically similar but contrasting groups: the very highest and lowest scorers on Tasks B and C.

Table 4.5: LEFTWARD AND RIGHTWARD RATIO DISTRIBUTIONS BY TYPE OF CONTACT

	Task B		Task C	
	Highest (100%)	Lowest Quartile	Highest (100%)	Lowest (0%)
Scorers:	n: 15	12	13	12
l/a:	3	1	5	0
Ratios:				
Placements and Collections*				
left-of-mean	3 (20%)	6 (50%)	7 (54%)	3 (25%)
right-of-mean	12 (80%)	6 (50%)	6 (46%)	9 (75%)
Placements				
left-of-mean	4 (27%)	5 (42%)	7 (54%)	3 (25%)
right-of-mean	11 (73%)	7 (58%)	6 (46%)	9 (75%)
Collections				
left-of-mean	6 (40%)	3 (25%)	8 (62%)	3 (25%)
right-of-mean	9 (60%)	9 (75%)	5 (38%)	9 (75%)
Assists				
left-of-mean	8 (53%)	4 (33%)	8 (62%)	5 (42%)
right-of-mean	7 (47%)	8 (67%)	5 (38%)	7 (58%)

*Contact ratios used to determine the THRs, the mean handedness ratios for each child on Tasks A-C

l/a: left-handed/ambidextrous children

The relative leftward and rightward ratio distributions of these children suggest the following associations between hand use and task success:

- Task B. Greater right-hand use when placing the cutouts in a progressive order according to size, less right-hand dominance when collecting the objects, and bimanuality in the assisting movements. (Note the progressive decreases in rightward ratios for the perfect scorers on Task B: from 73% for Placements, to 60% for Collections, and down to 47% for Assists.) When the Placement and Collection ratios of Task A are included in the calculations, there is both the greatest difference in the direction of hand movements of the highest scorers (with 80% of the ratios rightward versus 20% leftward) and the least difference among the lowest scorers (with 50% both rightward and leftward). It can therefore be assumed that using the right hand is also especially important in that task, sequencing pictures in a logical order.
- Task C. Less differentiation in hand use when repeating shape patterns, but an advantage for greater left-hand rather than right-hand use. (See the consistently slightly higher leftward proportions for the highest scorers versus the consistently, but also greater, rightward proportions for the lowest scorers.) The proportion of left-handed/ambidextrous children who have perfect scores is higher on this task (28% -- with none among the lowest scorers, versus 17% on Task B -- with the ambidextrous girl included among the lowest scorers, and representing one-half versus one-third of the left-handed/ambidextrous children in the study).

Conclusions are that the specific types of contact do provide additional information about the differentiated hand movements of the higher, and the very highest, scorers, and that differences between the tasks seem to be related to differences in the children's hand movements, i.e. that mentation and manipulations are connected.

SUMMARY

By each means of measuring the children's handedness -- their preferences when doing the various manual tasks of the Inventory and their contact frequencies when doing the three sequencing tasks (in the Main Study as well as in the Preliminary Study), the Irishman is right: The measures are different but the general results are the same. Leftward handedness lateralities are associated with the higher test scores. Lowest scores are of children whose handedness is more mixed. (This group of children also has the lowest incidence of a 'left factor' and includes only deaf children who use sign language, the three deaf children who have a 'high-risk' aetiology, and only one first-born deaf child.)

Differences between the tasks correspond to differences in the hand movements of the children when doing these tasks. Lowest scores, and the fewest very high scores, are on Task A, the task requiring the least amount of board space and on which the children's hand movements are the least lateralized, and the task that would seem to involve the highest degree of interhemispheric communication and cooperation. On Task C, the spatial arrangement of shapes, the most board space is required, the children's hand movements are the most lateralized, and the greatest number of children score above the mean -- particularly the left-handed/ambidextrous children and the deaf children.

Differences also relate to the types of contact when the test materials are manipulated. Placement contacts show the greatest lateralization, the Collection and Assist contacts greater bimanuality. However, collectively, only higher

scorers differentiate their hand movements for these specific actions.

What remains to be determined is the relationship between each child's own Placement, Assist, and Collection handedness ratios. These individual handedness patterns are described in the following chapter.

CHAPTER 5

HANDEDNESS PATTERNS

*I'll ha'e nae hauf-way hoose, but aye be whaur
Extremes meet--*

Hugh MacDiarmid
(A Drunk Man Looks at the Thistle)

In this chapter, the relationship between the hand movement patterns and the scores of each of the 60 children in the Main Study is discussed. Together with the general results reported in the previous chapter, the analyses of samples of children discussed in the next chapter, and the descriptions of six children presented in Appendix G, we can see -- as far as words and numbers can let us see -- the various ways the children used their hands when doing the sequencing tasks and how these ways relate to how well they did on the tasks.

The score-ratio plots of the figures in the preceding chapter are deceptive: The dots are static yet represent *actions* -- the children's external hand movements and their internal mental activity. Representing but not identifying each child, they do not tell us how the score-ratio distributions for all the children correspond to the specific score-ratio combinations of individual children: Which dots on the graphs represent which children? For instance, do the furthest left red dots on each of the three tasks in Figure 4.3 represent the *same* deaf child? Might there be a general pattern of success-related ratios, e.g. of a child's highest score being matched with his most, next most, or least lateralized hand movements? Might hearing status, age, or other differences be detected in the children's individual handedness patterns?

ANALYSES

To attempt to answer these questions, the data were cross-analyzed. The analyses are reported, again, from the most general to the most particular data: first, the *mean task ratios* (one for each task, totalling three for each child);

next, the *mean contact ratios* (for Placements, Assists, and Collections) on Tasks B and C (six for each child); and last, every contact ratio on every set of the three tasks (33 for each child).¹

How often a child contacted the test materials with his right or his left hand is associated with task success. Handedness patterns related to higher scores show complementary hand use with reciprocal dominance for different functions. This specialization and flexibility contrasts to nondifferentiation and consistency, as seen in the hand movements of children with lower scores. Specific favourable patterns include the following (which are referred to by number in the analyses reported):

1. Stronger lateralization of right- and left-hand movements.
2. Greater left- and right-hand differentiation according to a) the type of contact and b) the task.
3. Greater left-hand than right-hand dominance.
4. Greater variation in dominant left- and right-hand use.
5. Exclusive left-hand Collections of the materials.
6. Specification of right-hand-dominant movements for Placements and left-hand-dominant movements for Assists and Collections.

The deaf children collectively differ disadvantageously from the hearing children in their more moderate ratios -- less rightward for Placements and less leftward for Assists and Collections. They resemble the left-handed/ambidextrous children, who are higher scorers, a) in the progression of highest ratios combined with highest scores on Task C to lowest ratios combined with lowest scores on Task A, and b) in their lower mean range of Placement, Assist, and Collection ratios. They resemble the children within Band 2, who are lower scorers, in their greater consistency of either right-hand-dominant or left-hand-dominant actions.

¹What should be borne in mind is that the data base in these analyses is the same: the relative left- and right-hand frequencies of each child's placing, collecting, and assisting movements when doing the sequencing tasks. (Although a child is, say, deaf and male and left-handed and young, he is only one child and has only one score and one ratio e.g. for his Placements of the circus clowns.) Hence, there will be some repetitions in the trends reported.

1. Individual Score-Ratio Combinations on Tasks A-C. The highest, median, and lowest scores and ratios of each child were recorded. The totals of these score-ratio combinations are shown in Table 5.1a. The task scores refer to the per cent scores, as the age-adjusted scores (the ASDs) were calculated only on the children's total per cent (three-task mean) scores. The tied scores (all at 100%) of nine children are repeated in the highest score counts for those tasks (for six children on two tasks and for three children on all three tasks). Also duplicated are the tied ratios of one child (a left-hander whose highest ratios are $-.556$ and $.556$, on the tasks with his perfect scores).² The ratios are in reference to zero: The highest are the most lateralized, i.e. nearest $+1$ or -1 ; the lowest are the least lateralized, i.e. nearest zero.³

Table 5.1a: INDIVIDUAL SCORE-RATIO COMBINATIONS

Ratio:	Task A			|	Task B			|	Task C		
	H	M	L		H	M	L		H	M	L
Score:											
Highest	1 [2]	3 [0]	4 [3]	|	9 [3]	13 [5]	7 [0]	|	10 [3]	1 [1]	3 [4]
Median	1	8	7	|	4	11	5	|	7	6	2
Lowest	6	6	19	|	0	1	2	|	15	4	4
	$\overline{8}$ [2]	$\overline{17}$ [0]	$\overline{30}$ [3]	|	$\overline{13}$ [3]	$\overline{25}$ [5]	$\overline{14}$ [0]	|	$\overline{32}$ [3]	$\overline{11}$ [1]	$\overline{9}$ [4]

[Children who scored 100% on two or on all three tasks]

Not only collectively (as shown in the scattergrams of Figure

²Because other children have similar, although not identical, scores and/or ratios on at least two tasks, potentially causing a spurious highest/median/lowest distinction, a separate analysis was made. For each task, only those scores that differ by at least 10 percentage points and only those ratios that differ by more than .1 were compared. The distributions of these distinct scores and ratios (for 48% of all the children on Tasks A and C and 33% on Task B) are proportionally compatible with those of the total groups.

³For most (87%) of the children, the highest, middle, and lowest ratios are in a directional left-right or right-left continuum, e.g. Joel's ratios of $-.067$ (low and left), $.384$ (middle), and $.431$ (high and right). For only a few children (one ambidextral and six right-handers, a low 39% of the 18 children who have both negative and positive mean ratios on the three tasks), there is a discontinuity. For example, with Polly's three task ratios $-.033$, $-.483$, and $.589$, her lowest, nearest-zero, ratio ($-.033$) is not also her most leftward ratio; while $-.483$ is her middle ratio in extremity, it is not in the middle of a left-right continuum.

4.3) but also individually (as shown in the above table), low scores are associated with low ratios, high scores with high and median ratios. Of the three tasks, it is on Task A that most (52%) of the children have their lowest scores and most (55%) have their lowest ratios.⁴ Also, most (76%) of the lowest-score lowest-ratio combinations are on Task A. A contrast to Task C is that 61% of the Task A lowest scores are combined with lowest ratios, but 65% of the Task C lowest scores are combined with *highest* ratios. From these and the following results, as well as others reported previously, the task handedness ratios nearest zero are seen to be the least favourable.⁵

Of the six possible score-ratio combinations on the three tasks (for the 51 children without tied scores), the two that have the highest score combined with the highest ratio (an HH combination) on any of the tasks have, in addition to the most children represented, the highest proportions of above-mean

⁴The proportions of the hearing children who have their lowest scores and who have their lowest ratios on Task A are similar: 55% and 48%, respectively. The proportions of the deaf children are comparatively more disparate and differ in predominance: Fewer (45%) have their lowest scores and many more (70%) have their lowest ratios on Task A. (The outlier ratios *only* on Task A do not belong to deaf children.)

⁵An important exception is the Assist ratios. As shown in Figure 4.4 of Chapter 4, the Assist movements on both Tasks B and C were the least lateralized. For 55 (92%) of the children, the Assist ratio is the lowest (least lateralized) of the three contact ratios. (It is the lowest for 24 children on either Task B or Task C and for 31 children on *both* Tasks B and C. For no child is the Assist ratio the highest on both tasks.) For only two children, it is the highest on one task; for four other children, it is higher than either the Placement or the Collection ratio on both tasks. These six children whose Assist ratios are unusual have other anomalies: One is left-handed and one is ambidextrous; three are deaf; one has a squint. (That there are six, rather than five, exceptions is because the ambidextrous girl is counted twice: Her assist ratio on Task B is the highest of the three contact ratios, but on Task C, it is the lowest.) In fact, among those who have a higher task Assist ratio are seven of the nine left-handed/ambidextrous children and three of the five children with a squint. (The other two left-handed/ambidextrous children and one other child with a squint missed inclusion in the higher Assist group by .01 or less.) The four lowest-rank scorers in the study epitomize the anomalies: Each has at least one higher Assist ratio; one is left-handed and two have a squint; both who are deaf have the high-risk aetiology of birth complications.

scorers; lowest proportions, and fewest children, are of the highest-score and lowest-ratio combinations (HL), as shown in Table 5.1b.

Table 5.1b: CROSS-TASK SCORE-RATIO COMBINATIONS

Score-ratio combinations:	Number of children	
	<u>Hearing</u>	<u>Deaf</u>
HH + ML + LM	1 [1]	3 [2]
HH + MM + LL	11 [5]	5 [5]
HM + MH + LL	6 [3]	1 [1]
HM + ML + LH	5 [2]	5 [0]
HL + MH + LM	1 [0]	4 [1]
HL + MM + LH	8 [0]	1 [0]

H = highest, M = median, L = lowest scores (at left) and ratios (at right)

[Above-mean scorers]

A matching complementary to the HH combination, that of lowest scores with lowest ratios (LL), also appears advantageous, particularly among the deaf children, as all of them with this combination are above-mean scorers (versus only one of the nine deaf children with the most mixed pairs who scored above the mean). The triple pairing (HH + MM + LL) not only is associated with success and is the most common combination (for 31% of the children, versus a chance incidence of 17%); it also is in a straight task progression, the highest scores and ratios on Task C down to the lowest on Task A, for seven children -- a serial compatibility for 14% of the children, in contrast to a chance prediction of 3%. Of these children, again the deaf children have a preponderant representation: Three (60%) of the five deaf children, all above-mean scorers, have the Task C-B-A progression of their triple pairings (versus 36% for four out of the 11 hearing children). A further incidence which defies probabilities is that all five of the left-handed/ambidextrous children who do not have tied perfect scores have this triple pairing of their scores and

ratios, three of the children in the Task C-B-A order.⁶

In the lowest and highest score combinations, there are differences between the younger and the older children. Lowest scores are combined with median ratios only for older children on Task A and only for younger children on Tasks B and C. A more revealing difference is in the score group with the most children -- the 37 children whose highest (or tied highest) scores are on Task B. With 20 of them younger children, this 54% is similar to the 60% incidence of younger children among all the children. Yet of the seven who combine their highest score with their lowest ratio on Task B, all are younger children; all have below-mean total scores, and only one has one perfect score. In sharp contrast, 72% of the children whose total scores are above the mean combine their highest scores with their highest or median ratios on this task. (The children in this 72% group are the eight younger children and 13 of the 21 older children, including all 15 who have perfect scores on Task B). This implies that mixed handedness, shown in the lowest ratios, is particularly detrimental on Task B -- the task that visually shows the clearest directionality (the linear progression of smallest to largest objects) and that shows the greatest laterality of hand movements among those who are older and those who are most successful.⁷

⁶The high incidence of a triple matching serially from Task C to Task B to Task A among the left-handed/ambidextrous children corresponds exactly to the order of their mean scores: highest (at 79%) on Task C, median (at 74%) on Task B, and lowest (at 59%) on Task A. The superior performance of these children and the deaf children on Task C is shown in the increase in numbers of above-mean scorers on this task: Eight of the nine left-handed/ambidextrous children and 10 of the 20 deaf children scored above the mean on Task C, versus five each on Tasks A and B. Thus, these two groups especially show the relationship between highest scores and most extreme handedness ratios, and lowest scores and most mixed handedness, i.e., the advantage of using one hand dominantly on a task.

⁷Refer to a) the text and Figure 4.3 of Chapter 4 regarding the lateralization of the Task B perfect scorers and b) the contact consistencies of most Task B higher scorers, reported later in this chapter.

2. Range of Handedness Ratios. Not only in a child's highest and lowest mean ratios but also in the range of his ratios on each task, there are differences associated with success on Tasks B and C. A narrower mean range of the Placement, Assist, and Collection (PAC) ratios indicates less differentiation by the type of contact. We can see from Table 5.2 that of the score groupings, the lowest range is of the children who score below the mean on both Tasks B and C and the highest range is of the children who have perfect scores on both tasks.

Table 5.2: MEAN PAC RANGES BY SCORE GROUPINGS

	Number [deaf, lh/a*]	Mean PAC range (range)
Below-mean scorers on both Tasks B and C	17 [10, 1]	.599 (.267* - .963)
Above-mean but not perfect scorers on both Tasks B and C	17 [4, 2]	.756 (.353* - 1.343)
Above-mean scorers on Task B only	7 [0, 0]	.799 (.608 - 1.257)
Above-mean scorers on Task C only	12 [5, 3]	.815 (.363* - 1.368)
Perfect scorers on both Tasks B and C	7 [1, 3]	.838 (.240* - 1.301)

All 60 children		.738
Hearing children		.787
Deaf children		.639
Right-handed children		.770
*Left-handed/ambidextrous children		.554

A comparison of the ranges is provided by the two groups each consisting of 17 children -- those who scored below and those who scored above the mean on both Tasks B and C. (The seven children who have perfect scores on both tasks are listed separately, as they disallow a better-worse score comparison on the two tasks.) Regarding scores, there is a similarity in the two groups: 15 of the below-mean scorers and 14 of the above-mean scorers have higher scores on Task B than on Task C (together a 15% higher incidence than for all the children). However, regarding the range of their ratios, there is a difference between the groups. While the below-mean scorers collectively have no task differentiation in the range of their ratios (nine having a greater range on Task B and eight on Task C), the above-mean scorers do have a task differentiation: 14 (82%) of them have a greater range on Task C. This differentiation is accentuated in the higher mean

range of the children with above mean scores on Task C only and is suggested in the highest mean range of the children with perfect scores on both tasks. Therefore, the lack of specification regarding both type of contact and task, shown by the lower scorers, clearly seems detrimental to success.

Other differences, also shown in Table 5.2, relate to hearing status and categorical handedness. All seven of the children who are above-mean scorers on Task B only are hearing and right-handed -- and their *minimum* mean range is the highest (.608). The other, lower, minimum ranges all belong to left-handed/ambidextrous children. (The very lowest, at .240, is that of perfect-scoring, ambidextrous Joel; the .363, for the Task C higher scorers, belongs to Samuel, who is left-handed and deaf.) A discrepancy, then, is that the left-handed and ambidextrous children have both higher test scores and the lowest mean range of their handedness ratios (at .554, with the mean range still lower, at .512, for the left-handers alone).

The lower mean range of the deaf children than the hearing children, by .148, would seem insignificant were *highest* ranges not examined. Of the 16 children whose mean range is greater than .9, only one is a deaf child. Also notable about the children with the highest mean ranges is that only one child (Sean, the youngest of all the children) scored below the mean on both tasks; i.e., the other 15 scored above the mean on at least one of the two tasks. Thus, the children who have the greatest range in their manual contacts with the materials comprise 35% of the above-mean scorers versus 6% of the below-mean scorers.

A related question is whether there are success-associated individual differences in the *direction* as well as the degree of manual laterality on Tasks B and C.

3. Extreme Right- and Left-Handedness Ratios. In this analysis, the children were first grouped according to the task on which their more extreme ratio was attained -- whether

on Task B or Task C. (For example, Lucy, who typifies the relationship, and is described in Appendix G, was classified as Task C because her Task C ratio of .917 is more rightward than her Task B ratio of .219.) Next determined was if the child's higher or lower score was attained on that task. (Lucy's Task C score was the lower -- zero versus 33% on Task B).⁸ The results are shown in Table 5.3. (The seven children who scored 100% on both Tasks B and C are included, three within the separate left-handed/ambidextrous itemizations.)

Table 5.3: COMPARISON OF TASKS B AND C EXTREME RATIOS AND SCORES

		Task B scores higher/100% x2		Task B scores lower	
		rh	lh/a	rh	lh/a
Task B ratios	the more positive	13	0	3	1
	the more negative	3	3	0	0
<hr/>					
		Task C scores higher/100% x2		Task C scores lower	
		rh	lh/a	rh	lh/a
Task C ratios	the more positive	9	2	22	0
	the more negative	0	3	1	0

rh = right-handed children (n = 51)

lh/a = left-handed/ambidextrous children (n = 9)

On Task B, both the more positive and the more negative ratios are associated with higher scores: the more positive for 76%, the more negative for 100% (even for three right-handers). On Task C, however, the more positive ratios are contrarily associated with lower scores: 22 (67%) of the 33 children with more positive ratios on Task C (71% of the right-handers) have lower scores -- a positive ratio prevalence and apparent punishment. Of these 22 children, 16 (73%) are younger than the mean age. This proportion of younger children is greater than the 60% for all the children in the study (also than the 45% for the children with Task C positive ratios and higher scores, and the 31% for the children with Task B positive ratios and higher scores).

⁸Separate calculations were done for the 14 children whose ratios are negligibly, less than .01, more positive or more negative (seven children on Task B and seven on Task C) and for the 12 children whose scores on the two tasks differ by only one score grade (six lower and six higher on Task C than Task B). Neither these nor the hearing-deaf differences are indicated in the following table, as they are evenly dispersed.

Another comparison is with the 12 of these 22 children who are in the middle-right band of the Inventory Handedness Ratios: 10 (83%) of them have scores below the hearing/deaf means -- still more than the 65% of all the children in Band 2 who have below-mean scores. There could be a double jeopardy, of overall mixed handedness with right-hand dominance on Task C (and a potential triple jeopardy, for exclusive right-handed *Placements* of the shapes, as was discussed in Chapter 4). In hemispheric terms, the implicit correspondence indicates less efficient left hemisphere processing for these sequencing tasks among the low scorers, particularly among younger children, as well as a penalty for less specialization.

4. Positive and Negative Mean Ratio Combinations. Having a greater handedness range in the Placement, Assist, and Collection contacts and having extreme right and left ratios imply but do not confirm that the child combines dominantly right- and dominantly left-hand movements, i.e. positive and negative mean P, A, and C ratios on a task.

In Table 5.4a, the children who showed variable left-hand and right-hand dominance and those who showed consistency in either left-hand-dominant or right-hand-dominant contacts are grouped, as before, by their scores.

Table 5.4a: VARIATION VERSUS CONSISTENCY OF MEAN PAC CONTACTS

	Variation			Consistency		
	H	D	T	H	D	T
Below-mean scorers on both Tasks B and C (n = 17)	5 [0]	5	10 (59%)	2 [1]	5	7
Above-mean but not perfect scorers on both Tasks B and C (n = 17)*	7 [2]	2	9 (53%)	6 [0]	2	8
Above-mean scorers on Task B only (n = 7)	2 [0]	0	2 (29%)	5 [0]	0	5
Above-mean scorers on Task C only (n = 12)	6 [1]	2	8 (67%)	1 [2]	3	4
Perfect scorers on both Tasks B and C (n = 7)	5 [2]	0	5 (71%)	1 [1]	1	2
	25 [5]	9	34 (57%)	15 [4]	11	26

H = hearing; D = deaf; T = Total numbers of children
[Left-handed/ambidextrous children]

*The one child, mentioned in the text, who has an unusual combination of negative and positive ratios is included in this score group.

For 33 children, the range on either Task B or Task C consists of a negative and a positive ratio (regardless of the type of contact -- whether the negative or positive ratio is for the Placements, Assists, or Collections). One other child (a hearing left-hander) is included in this group, as he showed variation between tasks, having two negative and one zero mean ratio on Task B and positive mean ratios on Task C. Of these 34 children, 25 are hearing (60% of all the hearing children) and nine are deaf (45% of all the deaf children). Half of the 33 children combine positive and negative mean ratios on *both* Tasks B and C: Of them, 14 are hearing and two are deaf (35% and 10% of the respective totals).⁹

For 23 children, the Placement, Assist, and Collection mean ratios on both Tasks B and C are all positive. (All are right-handed except for one who is ambidextrous.) For three other children (left-handers), all six mean ratios are negative. Together, then, 43% of all the children placed, adjusted, and collected the cutouts and shapes with complete mean consistency of handedness.¹⁰

The lesser degree of variation of the deaf children is shown also in the below-mean scorers. As their mean PAC range is lower, so is their incidence of combining positive and negative mean ratios *on both tasks*: 12% (for two of the 17 below-mean scorers on Tasks B and C) versus 33% for (14 of the 43) above-mean scorers. Actually, as shown in the table, a slightly higher proportion of the children scoring below the mean on both tasks do combine positive and negative ratios *on one task* (59%, for 10 of the 17 children), compared to those

⁹The combination is of the Placement mean ratio that is positive with the Collection ratio that is negative (either the only negative or the more negative ratio) on one if not both tasks for 29 (88%) of the 33 children.

¹⁰The children whose P, A, and C contacts *on each set* of Tasks B and C are either all right-hand dominant or all left-hand dominant (i.e. whose 15 Tasks B and C ratios are all positive or all negative -- not only their three mean contact ratios per task) are described at the end of this discussion of consistency.

who scored above the mean on either or both tasks and also have positive-negative combinations on one task (53%, for 23 of the 43 children). The important difference is that more of the better scorers used alternate hands for the different contacts on both tasks.

By tasks, variation would appear to be more important in Task C than in Task B. (The highest consistency of the Task B higher scorers relates to the greater laterality on Task B reported previously.) As shown in the preceding table, twice as many of the Task C higher scorers show variation rather than consistency. Also, among the best and worst scorers, variation on Task C appears advantageous: Four of the five two-task perfect scorers with positive and negative ratio combinations (positives for Placements and negatives for Collections) have their varied ratios on Task C (the other child also on Task B). Conversely, of the two-task below-mean scorers, it is only on Task C that five children have consistently positive ratios -- and their lower score.

Of the children who combine positive with negative mean ratios on both Tasks B and C, the nine whose negative ratios on both tasks are greater than .1 illustrate the systems of consistent variation the children adopted *on the task(s) with their high/higher scores*. With one exception, these children (one ambidextral, the others right-handers) complemented their positive Placement ratios *on each set* of those tasks with negative Collection or Assist ratios. The child who is an exception (Jessica -- see Appendix G) also contrasted her positive and negative ratios on, and only on, the task with her higher (albeit below-mean) score, but reversed the positive ratio for the Collection and the negative ratio for the Placements on one set. The oldest of these children (and the oldest of all the hearing children, Nathan) has a further refinement, possibly an advanced system: task specific negative-positive combinations in the sets of these tasks with above-mean scores. (His positive Placement ratios are combined with negative ratios for the Assists and .019 and 0 ratios for Collections on the two Task B sets, but with

positive ratios also for the Assists and negative ratios for the Collections on the three Task C sets.)¹¹

Also of interest, again, are the 26 children whose Inventory Handedness Ratios are within Band 2 -- those with greatest mixed handedness, the group whose enigmatic composition is of both extremely good and extremely poor scorers, but with a preponderance (17 children, for 65%) scoring below the age-adjusted mean. While the numbers of all the children who combine positive and negative ratios on both tasks are evenly divided above and below the ASD mean (eight each), those in Band 2 are not: Of the 10 children in Band 2 who have two-task positive and negative ratios, six have above-mean scores and four have below-mean scores. Because of the score skew within Band 2, the proportions are 67% for those above to 23% for those below the mean. Variation distinguishes these outstanding scorers also.

A final probe into the issue of consistent manual laterality further differentiates the hearing and the deaf children. The reported lower incidence among the deaf than the hearing children of combining positive and negative mean ratios on Tasks B and C corresponds to a higher incidence among the deaf children of using one hand dominantly for each contact on each set of each task. In the following tabulation (Table 5.4b), zero ratios (for Placements, Assists, or Collections) are disregarded. The bracketed numbers are with a stricter criterion: for only positive or only negative (i.e. no zero) ratios within a set.

¹¹For reference to Appendix B.1, the two children with above-mean scores on Tasks B and C are Nathan and Max; those with above-mean scores on either Task B or Task C are Beth, Murdo, Kathryn, Imran, and Nana; the children with below-mean scores on both tasks are Jessica and Sean.

Table 5.4b: CONSISTENT P, A, AND C CONTACTS PER SET

	Task A only (6 sets)		Task B only (2 sets)		Task C only (3 sets)			Tasks B & C (5 sets)		Tasks A-C (11 sets)	
	+++	---	+++	---	+++	---		+++	---	+++	---
Hearing children (n=18) [n=9]	0 [0]	0 [0]	5 [2]	2 [0]	6 [6]	0 [0]	|	5 [1]	0 [0]	0 [0]	0 [0]
Deaf children (n=13) [n=9]	1 [0]	0 [0]	1 [1]	1 [0]	1 [3]	0 [0]	|	3 [3]	1 [2]	4 [0]	1 [0]

+++ = Placement, Assist, and Collection contact ratios either positive or zero
[all positive]

--- = Placement, Assist, and Collection contact ratios either negative or zero
[all negative]

With the more liberal measure of consistency, 31 children (one child more than half of the study population) are represented: 18 (45%) of the hearing children and 13 (65%) of the deaf children. Specific dissimilarities between the deaf and the hearing children relate to the numbers of sets on which all contacts were consistently either right-hand dominant or left-hand dominant.

When simply the numbers of children with any incidence of consistent one-hand dominance are counted, the deaf children have a lower representation (42% of the 31 children, versus 58% for the hearing children). However, while most of the hearing children (13 of the 18, for 72%) have consistent handedness on *one* task, most of the deaf children (nine of the 13, for 69%) have consistent handedness on at least two of the tasks. (See here and later the Tasks B and C and Tasks A through C numbers in the table.) No hearing child used one hand dominantly on all six sets of Task A (none, therefore, on all three tasks). In contrast, six deaf children did use one hand dominantly throughout Task A, five of them on all 11 sets of the three tasks.

By tasks, the incidence of consistency is as would be predicted: lowest on Task A, with the most sets; highest on Tasks B and C, with the fewest sets. On these two tasks the hearing and the deaf children are divided as evenly as possible (respectively, 12 and 11 on Task B, 11 and 10 on Task C). Therefore, relative to the number of 40 hearing and 20 deaf children in the study, the representation of deaf children on Tasks B and C is two-times greater (and is

exorbitant on Task A). Also, among the left-handed children (exclusively those with the negative ratios), the representation is 50% for the two who are hearing versus 100% for the three who are deaf, but is skewed further by the numbers of sets on which all contacts were left-handed: on a total of four sets for the hearing left-handers versus on a total of 18 sets for the deaf left-handers.

With the stricter criterion, identifying the children whose three ratios on a set are either all positive or all negative, the numbers of deaf and hearing children remaining are identical (nine each); thus, this representation of the deaf children is twice that of the hearing children. While representations are equal for consistent handedness on one task (eight hearing and four deaf children), the incidence of two-task consistency is 2.5% for (one of) the hearing children in the study versus 25% for (five of) the deaf children -- few children but a ten-fold difference, an amplification of the directions within the whole group.

Among the 13 deaf children, the proportion of the four oral children is 31%, which is commensurate with the 30% representation of the six oral children among the 20 deaf children in the study. This parity also is general but not specific. As none of the oral children are excluded with the stricter criterion, their proportion among the nine deaf children increases to 44%, and is further elevated to 60% for the three of them among the five deaf children who have consistent ratios (all positive or all negative) on both Tasks B and C.

Therefore, on this measure of greatest manual consistency, with disadvantageous associations, the deaf children, and particularly the oral deaf children, predominate. Furthermore, this 'sameness' of the deaf children's hand movements could relate to, as it reverberates, the sameness seen in the errors of the deaf children (reported in Chapter 3).

5. Exclusive One-Handed Contacts. In this analysis, continuing with the children's most definitive ratios -- the 33 Placement, Assist, and Collection ratios on each set of the three tasks, those that are +1 and -1 were investigated separately. These most extreme absolute ratios, which indicate exclusive right-hand (+1) and exclusive left-hand (-1) contact with the materials, can reveal continuities and contrasts -- important elements of systematic manual lateralities of individual children. An additional implication is that such total one-hand movements in Placement or Collection contacts will more probably cross the child's midline (hypothesized to be a positive attribute, quantitated separately and reported in Chapter 6). From preceding analyses, the -1 ratios, of exclusively left-handed contacts, could be expected to impact more than +1 ratios on successful task performance.

Shown in Table 5.5 are the numbers of children who used only one hand throughout a set to place or collect the materials, or to assist in these movements (e.g. transferring objects always from the right to the left hand).¹²

¹²Note that a child is counted if on at least one set of a task his contacts were exclusively one-handed. Other repeated instances are not indicated, e.g. if a child both placed and collected all the materials on one task, or on two tasks, with one hand exclusively. However, the 'Tasks A-C' numbers indicate how many children contacted the materials on at least one set in *all three tasks* exclusively with their right- or left-hand (or, as shown in the '+1 and -1' column, combined exclusively right-handed and exclusively left-handed contacts on sets within a task).

Table 5.5: ABSOLUTE PLACEMENT, ASSIST, AND COLLECTION CONTACTS

	+1		-1		+1 and -1		Total	
	H	D	H	D	H	D	H	D
	(Percentages of the 40 hearing and 20 deaf children)							
<hr/>								
TASK A (6 sets)								
Placements	30		8		1		39	
(on 1-6 sets)	22 (55)	8 (40)	6 (15)	2 (10)	0	1 (5)	28 (70)	11 (55)
Assists	4		2		0		6	
(on 1-3 sets)	0	4 (20)	1 (3)	1 (5)			1 (3)	5 (25)
Collections	22		11		10		43	
(on 1-6 sets)	13 (33)	9 (45)	8 (20)	3 (15)	7 (18)	3 (15)	28 (70)	15 (75)
<hr/>								
TASK B (2 sets)								
Placements	21		0		0		21	
(on 1-2 sets)	16 (40)	5 (25)					16 (40)	5 (25)
Assists	0		0		0		0	
Collections	26		10		2		38	
(on 1-2 sets)	16 (40)	10 (50)	6 (15)	4 (20)	2 (5)	0	24 (60)	14 (70)
<hr/>								
TASK C (3 sets)								
Placements	38		0		0		38	
(on 1-3 sets)	26 (65)	12 (60)					26 (65)	12 (60)
Assists	0		0		0		0	
Collections	22		15		3		40	
(on 1-3 sets)	11 (28)	11 (55)	10 (25)	5 (25)	2 (5)	1 (5)	23 (58)	17 (85)
<hr/>								
TASKS A-C (11 sets)								
Placements	44		3		6		53	
(on 1-8 sets)	31 (78)	13 (65)	2 (5)	1 (5)	4 (10)	2 (10)	37 (93)	16 (80)
Assists	4		2		0		6	
(on 1-3 sets)	0	4 (20)	1 (3)	1 (5)			1 (3)	5 (25)
Collections	24		11		21		56	
(on 1-11 sets)	15 (38)	9 (45)	8 (20)	3 (15)	14 (35)	7 (35)	37 (93)	19 (95)

H = hearing; D = deaf

The incidences when no child used one hand exclusively ('0' in the tabulation) are conspicuous and consistent: In addition to no completely left-handed contacts for Placements on Tasks B and C, there are no completely left-handed or right-handed

contacts for Assists on either of these tasks.¹³

However, for assisting contacts with the picture cards of Task A, six children did use one hand exclusively. These contacts correlate negatively, and significantly, with the children's age-adjusted scores ($r_s = -.250$, $p < .05$, for +1 Assists; $r_s = -.244$, $p < .05$, for the -1 Assists of the right-handers) -- also when the numbers of sets are calculated ($r_s = -.224$ and $-.223$, $p < .05$, respectively for +1 and -1 Assists). This result is compatible with another reported earlier -- that more equivalent right-hand and left-hand Assist contacts are associated with highest scores. That five of these six children are deaf relates to other incidences discussed next.

For the deaf children, there are disadvantages also in their exclusive right-handed movements for placing and for collecting the objects. On each task (separately and together), proportionally fewer of the deaf than the hearing children placed all the objects of a set with their right hands, but proportionally more of the deaf children collected them all with their right hands. These incidences are contrary to what is generally advantageous: a) The numbers of sets with +1 Placement ratios correlate positively with scores, at a level of statistical significance for the 51 right-handers ($r_s = .270$, $p < .05$); and b) the numbers of sets with +1 Collection ratios have negative correlations with scores ($r_s = -.131$, $p = .179$, for the right-handed children; $r_s = -.159$, $p = .112$, for all the children).

Least difference between the deaf and the hearing children in the +1 Placement ratios is on Task C, the task on which their

¹³Only one of the 60 children never used one hand exclusively (i.e., not on any set of the three tasks). She and two of the four children who have no absolute ratios on two tasks are deaf. Only on one task with no +1 or -1 ratio is the number of hearing children greater than of the deaf children: 12 versus two. The three-task monopoly (of the one deaf child) and the two-task majority (of three deaf children) for those who did not use either hand exclusively is another indication of greater bimanuality among the deaf children.

scores are the most similar. Also, there is less difference between the children in their combining +1 and -1 ratios on sets within tasks, and, importantly, in their exclusive *left-handed Collections*, which are described next.

Exclusive left-handed Collections: The -1 Collection ratios were examined separately, as they correlate significantly with both the ASDs and the total per cent scores ($r_s=.237$ and $.243$, respectively, at $p<.05$, for all the children; $r_s=.258$, $p<.05$, and $.192$, $p<.1$, respectively, for the right-handers). Age, as these correlations suggest, is not an influencing factor ($r_s=-.0002$, $p=.499$, for age by number of -1 Collection ratios); nor is hearing status (M-W $U=364.5$, two-tailed $p=.555$). (Proportions of hearing and deaf children are similar or identical regarding the numbers of sets on which they have -1 Collection ratios. The single difference is when the deaf representation is two times greater: for those whose only -1 Collection ratios are on Task C.)

Furthermore, a -1 ratio is selectively beneficial for Collections. As mentioned before, for Assists, both -1 and +1 ratios have negative correlations with scores. Also, the -1 Placement ratios, that are only on Task A, are associated with low scores for the six children who are right-handed ($r_s=-.333$, $p<.01$). (These are the only absolute contacts that approach significance in their correlation with age [$r_s=.184$, $p<.1$].)

A total of 32 children collected all the objects in one or more sets exclusively with their left hands.¹⁴ While 53% of the children in the study are in the '-1 C' group, representations of perfect scorers are higher on each task: 67% (for four of the six perfect scorers) on Task A; 80% (for 12 of the 15) on Task B; 77% (for 10 of the 13) on Task C. The -1 C group

¹⁴Included in this group are the nine left-handed/ambidextrous children. Four left-handed children and one right-handed child have at least one -1 C on each of the three tasks (one left-hander on 10 of the 11 total sets). Another nine children, of whom six are right-handed, have -1 C ratios on two of the tasks.

includes the three children who have perfect scores on the three tasks and five of the six other children who have perfect scores on any two tasks. The seven children with perfect scores on both Tasks B and C all have -1 Cs on Task C (five of them on one or both other tasks as well).

There is a further association of the children's -1 C ratios with the task on which their score is highest, and of combining a +1 Placement ratio with a -1 Collection ratio on a set. The following examples are of children whose scores, hearing status, and categorical handedness differ.

- Nana's only above-mean score is on Task C -- the task on which all her Collection ratios are -1, one combined with a +1 Placement ratio;
- Beth and Lawrence each have only one -1 ratio, on Task B -- their only task with an above-mean score;
- Simone has no above-mean score, yet her highest score is on the task (B) with her only -1 C ratio;
- Samuel and William have a -1 C ratio on Task B, with below-mean scores, but all three Collection ratios of -1 on Task C, with their above-mean scores (Samuel's perfect score);
- Mhairi at first seemed to be an exception, as her score on Task C is lower than on Task B (56% versus 100%), and it is on Task C that she has a -1 C ratio. Yet on that one set with a -1 ratio for the Collection and a +1 ratio for the Placements, she made no error. Furthermore, all her errorless sets (that set of Task C and both sets of Task B) combine negative and positive ratios; i.e. only on the two sets (1 and 2 of Task C) with errors are her PAC ratios all positive. Thus, she is an exemplification of, rather than exception to, two rules.

The +1 counterpart of the -1 ratios emphasizes a superiority reported in Chapter 4: the superiority associated with -1 ratios (i.e., not only with the -1 Collection ratios). An example is the large group of children who have +1 ratios on Task C: Ten placed, four collected, and two both placed and collected all 27 of the shapes exclusively with their right

hands.¹⁵ None of these children scored 100% on Task C, and only one (6%) has a -1 ratio on this task. (That exception, mentioned above, is Mhairi, whose -1 Collection ratio complements her +1 Collection ratio.) Three (19%) of these children scored 100% on one of the other tasks. There are two contrasts to be mentioned: a) Of the five children who collected (none placed) all the shapes exclusively with their left hands, three (60%) have perfect scores on Task C, two (40%) of them also on Task B (one on all three tasks). b) Of the 13 children who have perfect scores on Task C, eight (61%) have at least one -1 ratio on Task C. By lowest scores and by tasks, there are also relevant differences: Five (31%) of the 16 children scored zero on Task C, versus seven (16%) of the 44 other children in the study; the scores for 14 (88%) of the 16 children are lower on Task C than on Task B, versus for 23 (52%) of the all the other children. Thus, these consistent +1 ratios are associated with least success, whereas the -1 ratios are associated with greatest success.

6. Correlations of Handedness Ratios and Scores. In this final analysis, as in the first, the mean handedness ratios for each contact category on each task were used, but now to examine the associations between the different types of contact and the children's scores (both the per cent scores and the ASDs).¹⁶ Patterns discernible in the mean ratios of the

¹⁵Of these 16 children, 12 (75%) are included in the group of 26 right-handed children who have only positive or zero P, A, and C ratios on all the sets of at least one task (see Table 5.4b). Among those still included with the stricter all-positive criterion are the hearing and the deaf lowest age-ranked scorers. Both have +1 ratios for all Task C Placements and for two of the three Task C Collections. (Also, their Assist ratios on the five sets of Tasks B and C are all positive, three .5 or greater.)

¹⁶The mean ratios seem to be genuinely collective, i.e. to be determined not by a single child's or a few children's consistently having the left-most or the right-most ratio for each contact on each task. For example, among all 14 of the TC children, seven different children (only one of whom is left-handed) have the left-most ratios, and six different children have the right-most ratios (with one child having both a most leftward and a most rightward ratio). Therefore, only two (14%) of the TC children do not have one of the most extreme ratios.

51 right-handed children (Table 5.6) are first summarized, then compared to those when the left-handed/ambidextrous children are included.

Table 5.6: MEAN RATIOS OF RIGHT-HANDERS WITH SCORE CORRELATIONS

	MEAN RATIOS			Total	CORRELATIONS	
	Hearing	Deaf	Oral		%	ASD
n =	34	TC 13	4	51		
PLACEMENTS						
Task A	.331	.286		.316	<.02	<.005
		.305	.225		H:<.01	H:<.05
Task B	.528	.458		.505	NS	D:<.02
		.477	.398			NS
Task C	.783	.659		.742	NS	NS
		.641	.720			
Tasks A-C	.547	.468		.521	<.02	<.1
		.474	.448		H:<.05	
COLLECTIONS						
Task A	.198	.278		.225	NS*	NS*
		.283	.262			
Task B	.199	.419		.273	NS	NS*
		.457	.296			D:<.1
Task C	.180	.391		.250	NS*	NS*
		.401	.356			
Tasks A-C	.192	.363		.249	NS*	<.1*
		.380	.305			H:<.1*
ASSISTS						
Task A	.030	.178		.079	<.05*	NS*
		.160	.235			
Task B	.092	.162		.115	<.1*	NS*
		.142	.228		H:<.1*	
Task C	.122	.189		.144	<.1*	<.1*
		.178	.226			
Tasks A-C	.081	.176		.113	<.05*	NS*
		.160	.229		H:<.05*	

* = negative Spearman correlation coefficient

NS = nonsignificant ($p > .1$)

*Summary of the handedness patterns of the right-handed children:*¹⁷

- By contact categories, there is a progression from the most lateralized hand movements (the highest, most rightward, mean ratios) for Placements to the least lateralized hand movements (the lowest, most leftward, mean ratios) for Assists.

¹⁷Ratios that differ by less than .02 (for Assists) are shown in the table but not specified in the text. With these minimal differences disregarded, the statements are true for each group identified by hearing status, for each of the three contact categories, and for each of the three tasks.

- By tasks, the corresponding progression of the most to the least lateralized movements follows from Task C to Task B to Task A (for Collections, from both Tasks C and B to A).
- Correlations of the ratios with scores are positive for Placements but negative for Collections and Assists. That means that generally the more right-handed Placements of the materials but the more left-handed Collections and Assists are associated with the higher scores.
 1. The most and the highest correlations are of the ratios and scores for Placements on Task A. This would mean that especially on this task this action should be right-handed -- although it is the least likely to be.
 2. The hearing children consistently have both the highest Placement ratios and the lowest Assist and Collection ratios, i.e. handedness propitious for success. The ratios of the hearing children are significantly more leftward than those of the deaf children for the Task A Assists (M-W $U=160$, $p<.01$, collectively; M-W $U=127.5$, $p<.05$, with the TC deaf children and M-W $U=32.5$, $p<.1$, with the oral deaf children). For the Tasks A-C Collection ratios, the difference approaches significance (M-W $U=205$, $p<.1$, collectively, and M-W $U=145$, $p<.1$, with the TC children).¹⁸
 3. While the Collection ratios of the right-handers all together and of those who are hearing correlate negatively with their scores ($r_s=-.216$, $p<.1$, and $r_s=-.264$, $p<.1$, respectively, with the ASDs), of those who are deaf, the correlation is positive on Task B and approaches significance with the ASDs ($r_s=.367$, $p<.1$). Also, the Task B Collection mean of the TC children is exceptionally high. Since the scores of the deaf children (as well as of the hearing children) are their highest on this task, this result is inexplicable.

When the nine left-handed/ambidextrous children are included in the calculations, all the mean ratios are more leftward. Differences relate to the six oral deaf children, two of whom are left-handed. (Their incidence of 33% contrasts to 7% for the TC deaf children who are left-handed, and 15% for the

¹⁸Along with the lower mean ratios for Collections on each task, hearing children have the lowest *individual* Collection ratios on each task. The *highest* individual Collection ratios are of hearing and deaf children.

hearing children who are left-handed or ambidextrous.) As a group, among all the children, their ratios are the lowest (most leftward) for each contact category on each task with one exception: For the Task A Assists, their ratios are still the most rightward (the hearing children's still the most leftward).

For all the children, the one Placement correlation that approaches significance is on Task A ($r_s=.208$, $p<.1$, with the ASDs). The Assist ratios of Tasks A-C correlate at the same level of significance with the per cent scores ($r_s=-.266$, $p<.05$), but the correlation of Task A Assist ratios with both scores increases ($r_s=-.308$, $p<.01$) with the per cent scores; $r_s=-.204$, $p<.1$) with the ASDs), and correlations on Task C are nonsignificant. For the Collection ratios of Tasks A-C, significance is approached with both ASDs and per cent scores ($r_s=-.197$, $p<.1$, and $r_s=-.190$, $p<.1$, respectively). The hearing-deaf differences remain: in the Task A Assists (M-W $U=243$, $p<.02$) and -- between the hearing and the TC children -- in the Tasks A-C Collections (M-W $U=181$, $p<.1$).

SUMMARY

The results of the six analyses of the handedness patterns of the individual children in the Main Study were summarized at the start of this chapter. The ways in which the children combined the actions of their left and right hands for placing, collecting, and assisting movements define and confirm the general implications reported in Chapter 4.

What can be added is the conclusion of the stanza that introduced this chapter:

--it's the only way I ken
To dodge the curst conceit o' bein' richt
That damns the vast majority o' men.

'Richt' in the directional sense also is true of the handedness of most people. Of the children in this study, dominant right-handedness not combined systematically with

left-handed movements seems to be if not a damnation then at least a disadvantage. As MacDiarmid and other Caledonian antisyzygists advocate, the combination of opposites, the meeting of extremes, is preferable -- not only for a drunk man looking at a thistle.

CHAPTER 6

SAMPLES

...the power of thine hand...

Proverbs 3:27

The handedness ratios from the Inventory activities and the sequencing tasks provide but one quantitative measure of manual laterality: frequency of contact. The Task Handedness Ratios have differentiated relative frequencies -- how often a child used each hand for each of the three types of contact and on each of the three tasks -- but not the relative *durations* of the right-hand and left-hand contacts.

In the types of errors the children made, the order in which a child placed and collected the materials was described (e.g. whether from the first at the left to the last at the right, vice versa, or with alterations; whether objects were placed in the order they had been presented or according to a seriation principle). Other differences are also important. For example, were contacts made with both hands simultaneously or with each hand alternately? Was a contact made with the arm extended ipsilaterally or across the body midline? Were the objects collected with a continuous one-handed movement along the board or were they transferred from one hand to the other, or put one-by-one into the envelope? Did a child's hand movements change from set to set within a task? And how might these differences relate to a child's success?

For these important variations, the actions of samples of children were analyzed. Twenty children were observed in the first sample reported, 12 in the second, and six in the third.

SAMPLE OF 20 CHILDREN

The children in this sample are hearing-deaf dyads: Half of the deaf children were paired with hearing children. The criteria for the 10 dyads were a) similarity of their Inventory Handedness Ratios and their task scores (i.e. proximity in the IHR-score plot of Figure 4.2a), b) compatibility of other factors (e.g. age, sex, and categorical handedness), and c) representative diversity. Balancing the pair of the hearing girl and the deaf girl who have perfect total scores is the pair whose scores are the lowest of all the girls. The pairs of boys include the ambidextrous hearing boy and the left-handed deaf boy whose ASDs are the highest of the hearing and the deaf children, and both the hearing and the deaf right-handed boys whose total scores are the lowest of all the children (and who are the youngest children in the study, in contrast to two of the deaf children in the sample who are the oldest). Also included in the sample are four of the five Main Study children who had had a squint detected.¹ The inclusion of these children with a vision problem does not detract from the compatibility of the sample with the total study population and does allow investigation of ways in which their handedness patterns might be unusual. Overall similarities between the children in the sample and all the children in the study are shown in Table 6.1a.

Table 6.1a: COMPARISONS OF THE DYADS AND TOTAL GROUPS

	IHR		THR		Age		% Score		ASD rank	
	m	d	m	d	m	d	m	d	m	d
Deaf children										
Sample (n=10)	.367		.295		4.76		47.3		9.0	
Total (n=20)	.371	.004	.289	.006	4.86	.10	48.4	1.1	10.0	1.0
Hearing children										
Sample (n=10)	.412		.257		4.07		59.5		21.3	
Total (n=40)	.451	.039	.292	.035	4.12	.05	60.5	1.0	20.0	1.3
<hr/>										
	Band 1		Band 2		Band 3					
Sample (20 children)	7 (35%)		9 (45%)		4 (20%)					
Total (60 children)	23 (38%)		26 (43%)		11 (18%)					

m = mean; d = difference

¹No hearing girl was similar enough to the other child (the only deaf child) with a squint for her to be paired and included in the sample.

Compatibilities *within* the sample are equal numbers of a) hearing and deaf children whose IHRs are to the left and to the right of the hearing/deaf means (three hearing and three deaf children to the left, and seven each to the right), and b) children whose THR is left and right of the mean and children whose total scores are above and below the mean (five-five divisions of the THR and scores for the hearing and for the deaf children). Among the deaf children in the sample, the four oral children and the six total communication children are also equally divided by total scores (half in each group scoring above the mean). Another compatibility is that the children in each dyad are both older or both younger than the median age of all the children in the study. General information about the 20 children is presented in Table 6.1b. (The six girls, who are described in detail, are listed together, and first.)

Table 6.1b: CHARACTERISTICS OF THE HEARING-DEAF DYADS

<u>Children</u>	<u>Age</u>	<u>% Score</u>	<u>IHR (Band)</u>	<u>THR</u>
Polly	4:3	100.0	.231 (1)	.024
Alice (TC)	7:0	100.0	.385 (1)	.490
Amelia	3:7	25.0	.467 (2)	.467
Jessica (TC)	3:10	27.3	.500 (2)	.092
Lucy	4:1	17.7	.692 (2)	.499
Simone (O)	3:9	20.0	.818 (3)	.266
Joel	4:0	100.0	-.286 (1)	.249
Samuel (O)	3:11	63.3	-.833 (1)	-.673
Liam	4:9	94.3	-.385 (1)	-.040
Duncan (TC)	4:9	66.7	-.692 (1)	-.132
Sean	3:0	15.7	.667 (2)	.138
Arthur (O)	3:1	9.0	.333 (1)	.566
Hamish	4:2	41.3	.538 (2)	.090
Jimmy (TC)	7:6	40.0	.692 (2)	.549
Max	4:8	89.7	.692 (2)	.369
Imran (TC)	5:4	58.3	.636 (2)	.216
Jonathan	3:11	28.7	.500 (2)	.369
Robert (TC)	3:7	25.3	.833 (3)	.733
Jasper	4:3	82.7	1.000 (3)	.402
Ali (O)	4:10	63.3	1.000 (3)	.843

Deaf children: TC = total communication
 O = oral mode of communication
 Left-handed/ambidextrous children

For these 20 children, three movement patterns are reported: the durations of contacts with the materials, the transfer of objects from one hand to the other, and reaches that cross the body midline.

A. Contact Durations

The intent of examining the durations of the contacts of these 20 representative children was 1) to determine the validity of an *a priori* relationship between frequency and duration, i.e. that if more contacts were made with one hand, the total contact time of that hand with the materials would also be greater; 2) to determine quantitatively the duration of two-handed simultaneous contacts relative to independent one-hand contacts -- a distinction not made previously.

The durations of all contacts (whether for placing, assisting, or collecting actions) that were made with only the right hand (R), with only the left hand (L), and simultaneously with the right hand and the left hand (RL) were recorded (in 1/100 seconds) separately for the three tasks. (As before, the Task A data are from the first six sets, those completed by all the children.)² The percentages of the time each hand alone and both hands together contacted the materials were calculated, and duration ratios for each single-hand contact (R/L ratios) were obtained from the actual times recorded using the same formula as for the frequency ratios (both the THRs and the IHRs): $(R - L) / (R + L)$.

The association between the duration and the frequency of contacts with the test materials is affirmed by the significant correlation of the R/L ratios with the THRs ($r_s = .602$, $p = .002$). The strength of this correlation is reflected in the equivalent correlations of the duration and the frequency ratios with the total scores (respectively,

²Duration times for five children were also obtained by a student unfamiliar with the study. (The children whose contact durations were verified are Polly, Alice, Joel, Samuel, and Sean.) The correlation of the times obtained by the student and by the researcher is highly significant ($r_s = .980$, $p < .001$).

$r_s = -.337$, $p < .1$, and $r_s = -.338$, $p < .1$).³

For this sample (one-third of the total Main Study population), the trend in these negative correlations derived from the duration counts does not alter, but emphasizes, the pattern seen in the handedness ratios derived from the frequency counts of all the children: the association of more leftward ratios with higher scores.

Table 6.1c: CONTACT DURATIONS

Children	Durations					Task A		
	Tasks A-C					R%	L%	RL%
	R%	L%	RL%	R/L Ratio*	Time**			
Polly	21	21	57	-.004	9.36	30>	19<=	51<
Alice (TC)	16	8	76	.330	5.79	19	8	73
Amelia	22	8	70	.442	12.99	34>	6<=	60<
Jessica (TC)	4	8	89	-.361	12.19	6>	7	87
Lucy	13	7	81	.324	13.43	30>	13>	57<
Simone (O)	12	8	81	.231	10.85	21>	2<	77<=
Joel	8	18	73	-.374	13.14	7<=	31>	61<
Samuel (O)	6	14	80	-.430	12.65	6	23>	71<
Liam	15	8	76	.303	10.00	16	16>	68<
Duncan (TC)	16	8	75	.323	13.67	21>	4<	75
Sean	27	12	61	.401	16.47	50>	13>	37<
Arthur (O)	17	5	78	.567	12.74	22>	3<=	76<
Hamish	24	18	58	.159	15.40	36>	45>	19<
Jimmy (TC)	14	11	75	.114	9.29	22>	34>	44
Max	13	20	67	-.213	18.07	10<	14<	77>
Imran (TC)	23	24	53	-.032	12.21	28>	26	47
Jonathan	17	5	78	.567	15.69	19	8>	73<
Robert (TC)	21	9	70	.410	14.16	20<=	17>	63<
Jasper	12	1	87	.807	7.64	19>	2>	79<
Ali (O)	28	2	70	.872	7.25	38	2>=	60

* Note that since the R/L ratios were calculated from the actual times of right- and left-hand-only durations, they cannot be calculated accurately from the percentage data in the table.

**Time, reported in minutes, is the total for all contact durations (right hand only [R], left hand only [L], and both hands together [RL]) on Tasks A-C.

>: Highest (or >=: tied highest) duration percentage of the three tasks
<: Lowest (or <=: tied lowest) duration percentage of the three tasks

Deaf children: TC = total communication
O = oral mode of communication
Left-handed/ambidextrous children
Children who had a squint

³The deaf children are mostly responsible for the significant duration-frequency correlation ($r_s = .818$, $p = .002$, for them, versus $r_s = .450$, $p < .1$, for the hearing children). However, the trend in the duration-score correlation depends on the hearing children ($r_s = -.626$, $p < .05$, versus a nonsignificant correlation for the deaf children).

Tasks A-C. The data for Tasks A-C in Table 6.1c show that for all these children, durations of simultaneous left- and right-hand contacts exceed the total durations of the exclusive right-hand and the exclusive left-hand contacts. The range of simultaneous two-hand contacts is from 53% for Imran to 89% for Jessica -- both within Band 2, deaf, and in TC classes. It is also deaf children, but deaf children in the oral class, who have the most leftward and the most rightward R/L ratios (at $-.430$ for Samuel, who is left-handed and within Band 1; at $.872$ for Ali, who is right-handed and within Band 3, and whose difference in right-hand versus left-hand durations is the greatest).

Regarding categorical handedness, two of the three left-handers in addition to 12 of the 16 right-handers had longer right-hand than left-hand contacts (and therefore have positive R/L duration ratios). Of the children with longer left-hand contacts (negative duration ratios), one is left-handed, one is ambidextrous, and four are right-handed. The one ratio, of Polly, is negligibly negative (as indicated in her equal right- and left-hand percentages). Of the other right-handed children who have longer left-hand durations, one is a hearing boy (Max, acknowledged by his mother to be 'left-hand dextrous'), and the other two are deaf children who sign (Jessica and Imran).

Other differences by groups are shown in Table 6.1d. 1) Collectively, the oral deaf children have both the highest percentage of two-handed contact durations and the greatest right-/left-hand difference (hence the highest R/L ratios). 2) These differences are seen also in the children within Band 3 (of whom half are oral deaf children), only now the right-hand durations are three, rather than two, times greater than those of the left hand. 3) The difference between the children whose age is above or below the median is that the older children have longer durations for single-handed contacts, with corresponding shorter durations for simultaneous contacts. Within the groups, the time of contact with the materials on the three tasks (shown individually in

the above table) is greatest for the hearing, the Band 2, and the younger children.

Table 6.1d: DURATION DIFFERENCES (Tasks A-C)

	<u>R%</u>	<u>L%</u>	<u>RL%</u>	<u>R/L d</u>	<u>R/L ratio</u>	<u>Time</u>
1) BY HEARING STATUS						
Hearing children (n=10)	17.2	11.8	70.8	8.8	.241	13.22
TC deaf children (n=6)	15.7	11.3	73.0	6.0	.131	11.22
Oral deaf children (n=4)	15.7	7.2	77.2	12.5	.310	10.87
2) BY IHR BANDS						
Band 1 children (n=7)	14.1	11.7	73.6	7.6	.102	11.05
Band 2 children (n=9)	17.4	12.6	70.2	7.6	.156	13.97
Band 3 children (n=4)	18.2	5.0	77.0	13.2	.580	9.97
3) BY AGE						
Younger children (n=10)	14.7	9.4	76.1	9.7	.178	13.43
Older children (n=10)	18.2	12.1	69.4	7.7	.266	10.87

d = mean difference in the R% and L% of the individual children
(Other abbreviations conform to those in the previous table.)

Task A. The duration percentages for Task A are shown separately in Table 6.1c because they specify how the children were using each hand within the most confined space, and reveal several atypical patterns.

Max is again an exception as he is the only child whose Task A contact durations were the longest with both hands simultaneously and the shortest with each hand independently. He is also one of the four right-handed children whose left-hand durations on Task A exceed their right-hand durations. All four of these children are in Band 2; the two who are deaf both sign. (Two are in the group described below.) Another deaf child who signs is an exception among the left-handed/ambidextrous children: Duncan's left-hand contacts are the shortest, and his right-hand contacts are the longest.

Particularly remarkable is a group of five right-handed children: Lucy, Sean, Hamish, Jimmy, and Jasper. They differ from all the other children by having used their right and their left hands alone for the longest time while handling the Task A (versus the Tasks B and C) materials. The four who also used both hands simultaneously for the shortest time during Task A are the four hearing children in the Main Study

who had a perceptible squint. Furthermore, the four who are within Band 2 all have below-mean scores: One child's total per cent score is the lowest of all the hearing children; two others' age-adjusted scores are the lowest -- Lucy's among the hearing children and Jimmy's among all the children.

The two children who used each hand most exclusively and the left versus the right hand for the longest time on Task A are Hamish and Jimmy. The coordination difficulties these two boys had when trying to put a rubber band around a box are reported in Appendix H.⁴ By the numbers of sets within Task A on which a child had a highest duration for left-hand-only contacts, Hamish had the most -- on five of the six sets; next was Jimmy, on two sets. Two other right-handed children had a highest left-hand-only duration on one set of Task A, and the other 16 children in the sample (i.e., 80%) on none. Correspondingly, Hamish had the lowest two-hand percentage (19% -- 18% lower than the next lowest percentage); only he and Imran never used both hands together on a Task A set.

These duration measures, therefore, support two general findings:

...the left handed are rarely so strongly unilateral as the right-handed. (Naidoo 1961, p. 204)

Deaf children are more variable as a population than hearing children. (Wood et al. 1986, p. 163)

They also identify children who have exceptional mixed handedness patterns, some associated with the visual anomaly of strabismus, with total communication, and with lower scores. Further study to explore the reasons for these

⁴Problems Hamish had with other Inventory activities are also reported in the Appendix. Doing the sequencing tasks, he had extreme difficulty in placing the shapes one-by-one into the envelope, held at his midline. He took as long as eight seconds under *five minutes* for one collection, and just under two minutes when he resorted to putting the shapes on, instead of inside, the envelope. Relevant information about Jimmy includes the aetiology of his deafness: prematurity; his only sibling: a hearing (first-delivered) twin brother; measures of his intelligence (tested when he was about three and five years old): IQ scores of 81-85.

associations would seem indicated.

B. Transfers and Crosses

To determine how the children coordinated the movements of both hands and used each hand independently, their transfers of the materials from one hand to the other and their midline crosses were analyzed. The transfer hand was defined as the hand to which an object was directly transferred. An exchange was not counted as a transfer when there was an interim two-hand hold or when one hand was passive, e.g. merely holding the pile of cards/cutouts/shapes from which one object was removed. The criterion of a cross was that the child's midline was actually crossed while materials were manipulated. Therefore, a child's gestures, signs, or postures that happened to cross his midline were not counted; nor were arm extensions when the child's body turned in the same direction, so that arm remained ipsilateral to the materials, i.e. did not cross the midline of his body.

The numbers of each child's right-hand and left-hand transfers and crosses on each of the three tasks were totalled, and the mean for each hand was converted, as before, into a ratio. The numbers and ratios for each child are shown in Table 6.1e.

Table 6.1e: NUMBERS AND RATIOS OF TRANSFERS AND CROSSES ON TASKS A-C

<u>Children</u>	<u>Transfers</u>			<u>Crosses</u>		
	R	L	ratio	R	L	ratio
Polly	13	15	-.071	1	6	-.714
Alice	28	27	.018	3	2	.200
Amelia	29	6	.657	16	10	.231
Jessica	30	18	.250	0	1	-1.000
Lucy	24	8	.500	6	0	1.000
Simone	7	29	-.611	1	0	1.000
Joel	5	15	-.500	1	2	-.333
Samuel	7	12	-.263	0	5	-1.000
Liam	16	56	-.556	2	4	-.333
Duncan	10	27	-.460	1	1	0
Sean	18	12	.200	1	0	1.000
Arthur	12	26	-.368	7	7	0
Hamish	32	5	.730	5	0	1.000
Jimmy	12	12	0	2	0	1.000
Max	33	14	.404	6	12	-.333
Imran	15	5	.500	25	8	.515
Jonathan	22	22	0	3	2	.200
Robert	29	13	.381	0	0	0
Jasper	31	1	.938	0	1	-1.000
Ali	17	16	.030	7	7	0

Deaf children; left-handed/ambidextrous children;
children who had a squint

The transfer ratios correlate significantly with the THRs only for the hearing children ($r_s=.590$, $p<.05$) and with the IHRs again for the hearing children ($r_s=.766$, $p=.005$) as well as for the total sample ($r_s=.523$, $p<.01$). In comparison with total scores, the correlations are positive but nonsignificant.

The crosses have no significant correlations with either the Task or the Inventory Handedness Ratios, but have a significant *negative* correlation with the children's total scores ($r_s=-.540$, $p<.01$). This correlation also is dependent upon the highly significant correlation for the hearing children ($r_s=-.779$, $p<.005$). This means that the more left-handed crosses, particularly of the hearing children, are significantly associated with higher scores.

The group of five children whose durations showed each hand most active alone on Task A seldom crossed their midline, and then exclusively with one hand: Jasper once with his left hand, and the others (those in Band 2) from one to six times only with their right hands. (The median number for all the

children is low: five times. Among these five children it is still lower: twice.) Transferring the materials from one hand to the other, all four of the children who had a squint have ratios that are positive and above the median (of .024); however, half of the other right-handers have below-median transfer ratios (i.e. a higher incidence of transferring objects to their left hands). Of all the children, the two who transferred materials more predominantly with one hand (and so have the highest transfer ratios) are Jasper and Hamish -- transferring objects mostly to their right hands (Jasper only once transferring an object to his left hand).

Thus, with all three measurements, there are consistent differences in the manual patterns of these few children who have specific problems. Their neglect of one hand and their independent use of each hand suggest a difficulty in coordinating the actions of both hands together. Their low scores associate their manual, and visual, differences with mental difficulties.

SAMPLE OF 12 CHILDREN

Because of the apparent importance of the body midline, three actions across or at the midline were explored with a smaller sample of 12 children. This diverse sample is composed of nine children from the hearing-deaf dyad sample (the six girls discussed as exemplars, one of the left-handed/ambidextrous dyads, and one of the hearing right-handed boys) plus three other right-handed girls. These three hearing children have no deaf counterparts but provide other contrasts that were thought might clarify the mixed skills of the right-handers who have mixed handedness. Joan and Claudia are both bilingual and both are in Band 2, but they differ in their sequencing abilities. Kathryn is similar to Jonathan regarding handedness ratios and age, yet they also differ in

their task performance.⁵ The eight hearing children were in the same nursery school; two of the deaf children were in a total communication school, and the other two were in the oral class.

Counts were made of the Placement and Collection actions on Task A. This task was selected because it allows linear sequencing within the most restricted distance; it has the greatest number of test sets; and it classically is, and within this battery was, the most difficult sequencing task -- the one hypothesized to require the greatest amount of hemispheric integration (and integrity, in the sense of wholeness and completeness). The three actions related to the midline that were analyzed are contralateral reaches, midline contacts, and continuity in the direction of movements.

A. Contralateral Reaches

Percentages were calculated for the numbers of contralateral contacts with the cards: those at the left of centre made with the right hand and those at the right of centre made with the left hand. The contralateral movements include reaches when the child's body position was rotated in the direction of the action as well as the midline crosses (when a reach actually traversed the child's midline). As a two-handed reach within the space at the left or the right involves a contralateral movement, the few two-handed contacts at points away from the centre are included in the contralaterality counts. The degree of contralaterality within the space at the left and at the right of the body midline when placing and when collecting the cards is shown in Table 6.2a for each of the 12 children. Percentages reported are for Task A sets 1-6. (For the seven children who completed all eight sets, the correlations of sets 1-6 and sets 1-8 are highly significant: from $r_s = .937$ to

⁵Kathryn's THR of .275 and her IHR of .429 are less than .100 more leftward than Jonathan's ratios, and she was only three months younger than he. However, Kathryn ranked eighth and Jonathan 35th among the 40 hearing children.

1.000, $m=.966$, $p<.001$.) The three deaf girls are grouped together, as are the additional contrasting dyads, and the left-handed and ambidextrous boys.

Table 6.2a: CONTRALATERAL REACHES (Task A)

		PLACEMENTS		COLLECTIONS		TOTAL	
		at left	at right	at left	at right	m	r
Polly	+	64% (9/14)	0% (0/3)	67% (6/9)	33% (1/3)	55% (16/29)	67%
Amelia	-	67% (18/27)	33% (9/27)	20% (1/5)	11% (1/9)	43% (29/68)	56%
Lucy	-	17% (1/6)	0% (0/10)	60% (3/5)	0% (0/7)	14% (4/28)	60%
Alice	+	80% (8/10)	0% (0/4)	30% (3/10)	25% (1/4)	43% (12/28)	80%
Jessica	+	50% (4/8)	10% (1/10)	0% (0/6)	0% (0/8)	16% (5/32)	50%
Simone	-	0% (0/3)	0% (0/7)	0% (0/4)	0% (0/7)	0% (0/21)	0%
Joan	+	50% (4/8)	0% (0/4)	33% (3/9)	75% (3/4)	40% (10/25)	75%
Claudia	-	0% (0/7)	0% (0/4)	17% (1/6)	0% (0/5)	4% (1/22)	17%
Kathryn	+	100% (7/7)	0% (0/7)	71% (5/7)	17% (1/6)	48% (13/27)	100%
Jonathan	-	0% (0/7)	0% (0/9)	0% (0/6)	0% (0/9)	0% (0/31)	0%
						+	40%
						-	12%
Joel	+	18% (2/11)	0% (0/5)	0% (0/6)	0% (0/6)	7% (2/28)	18%
Samuel	+	0% (0/18)	0% (0/4)	0% (0/10)	0% (0/3)	0% (0/35)	0%
M		(8)	(6)	(6)	(6)		
						m hearing	26%
						m deaf	15%
							49%
							33%

(n/n) = number of contralateral contacts/total number of contacts

(n) = greater (or equal) number of total contacts at left or at right within Placements and Collections

m = mean; M = median; r = range

+ = ASD above the hearing/deaf mean (n=5 right-handers)

- = ASD below the hearing/deaf mean (n=5 right-handers)

Deaf children; ambidextrous/left-handed children

Three children made only ipsilateral movements when contacting the materials. Of the other children, most contralateral movements were with their right hands within the space at the left. (The average is 43% at the left versus 12% at the right.) Among the right-handed children, a relationship is shown between scores and the act of traversing the midline -- using their right hands within the leftward space for Placements and also their left hands within the rightward space for Collections. The children who had contralateral movements within the rightward space only for Collections are four right-handed girls, all above-mean scorers. The contralaterality mean is higher and the range is greater for the right-handed higher scorers (respectively, 40% and 74%, versus 12% and 27% for the lower scorers). With less difference, the mean is higher and the range is greater for the hearing than for the deaf children (the mean,

respectively, 26% versus 15%, the range 49% versus 33%). The ambidextrous and left-handed children were exceptional in having high scores but predominantly ipsilateral movements.⁶

The total numbers of contacts (both contralateral and ipsilateral) within the space at the left and at the right of the midline are also informative: They indicate that a *leftward* orientation is associated with task success. Of the right-handed children, all but one of the five who have above-mean scores, but *only* one of the five who have below-mean scores, made at least as many contacts in the space at the left as at the right for *both* Placements and Collections.

Several children were exceptional in different ways:

- Amelia made over twice as many contralateral and total contacts as any other child. Only she made contralateral movements both at the left and at the right for both Placements and Collections. (Many of her Placements were two-handed simultaneous exchanges. Also to be noted is that her Task A score is 50% -- her highest.)
- Joan (who is bilingual) is the only child who had a greater proportion of contralateral movements with her left hand than with her right hand (for 75% of her Collection contacts).
- Claudia (the other bilingual child) is the only below-mean scorer who had a leftward spatial bias (a greater number of Placement and Collection contacts at the left than at the right).
- Jessica is an exception among the right-handed children who scored above the mean: Only she had no contralateral movements when collecting the cards and had fewer leftward than rightward contacts. Also, her score is the lowest of these five children.
- Kathryn is of special interest because all her Placement and all but two of her Collection contacts were made with her right hand within the space at the left *and* she had a balanced total number of contacts at the left and at the right -- the greatest equivalence of all the

⁶Although on the Task A sets 1-6, and set 7, Samuel had no contralateral contacts, on set 8, his Placements included four contralateral contacts: two with his right hand and two with his left hand.

children and with all four counts the closest to the sample medians. Therefore, her high degree of contralaterality was due to no spatial neglect but rather to her right-hand use within the leftward space.

In summary: The children in this sample who demonstrated an ability to make and to inhibit contralateral movements, and whose spatial orientation was biased to the left, were all successful at the sequencing tasks. In their actions they achieved both specialization and integration.

B. Midline Contacts

The contralateral and ipsilateral reaches account for the children's movements in the space at the right and at the left of the body midline. To complete the spatial possibilities, the numbers of contacts at the centre with either hand alone and with both hands together were counted. They are presented in Table 6.2b.

The Placement and Collection contacts are combined because the numbers of midline contacts are few: For the combined Placement and Collection midline actions, the range is from three to 15; the mean and median number is eight (two more for the hearing than for the deaf children). Differences between the Placement and Collection midline contacts (lost when the counts are combined) were minimal for all but three children.

- Lucy's left-handed contacts were all for Placements while her right-handed contacts were all for Collections.
- Simone had only right-handed midline Placements.
- Joel collected all the centre cards with both hands: For all his symmetrically placed sets, his Collection movement was a simultaneous sweep with his left and right hands into the centre, i.e. to include the middle card in the four three-card sets.

Table 6.2b: DISTRIBUTION OF MIDLINE CONTACTS (Task A)

		PLACEMENTS AND COLLECTIONS AT THE MIDLINE		
		with the left hand	with the right hand	with both hands
Polly	+	1 (10%)	8 (80%)	1 (10%)
Amelia	-	1 (33%)	1 (33%)	1 (33%)
Lucy	-	3 (43%)	4 (57%)	0 (0%)
Alice	+	3 (75%)	1 (25%)	0 (0%)
Jessica	+	0 (0%)	3 (75%)	1 (25%)
Simone	-	3 (30%)	6 (60%)	1 (10%)
Joan	+	1 (14%)	6 (86%)	0 (0%)
Claudia	-	1 (8%)	7 (58%)	4 (33%)
Kathryn	+	0 (0%)	6 (100%)	0 (0%)
Jonathan	-	5 (50%)	4 (40%)	1 (10%)
Joel	+	2 (13%)	4 (27%)	9 (60%)
Samuel	+	4 (44%)	4 (44%)	1 (11%)

(%) = highest contact percentage

Other notations are the same as in Table 6.2a.

Of the right-handed children, again there is a difference between the higher and lower scorers. The five who are above-mean scorers showed a greater dominance of one hand (the right hand for four, the left hand for one). The range of midline contacts with their dominant hand is from 75% to 100% ($m = 83\%$). In contrast, none of the five who are below-mean scorers used either hand so predominantly: Their lower range spans from 33% to 60% ($m = 52\%$).

Another measure of each child's handedness dominance is the difference between the two highest percentages (e.g. of 70% for Polly: the difference between the 80% for her right-hand-only contacts and the 10% for her left-hand-only and two-handed contacts). Again without overlap, the range of difference among the right-handers is higher for the higher scorers: from 50% to 100% ($m = 68\%$), versus from 0% to 30% ($m = 16\%$) for the lower scorers.

The degree of dominance seems to be a more important factor than the hand that is dominant. For example, of the three perfect scorers, handedness dominance at the midline varied: Polly made most contacts with her right hand, Alice with her left hand, and Joel with both hands together.

In summary: Among the right-handed children in this sample, all the higher scorers contacted the cards at the midline more predominantly with one hand than did all the lower scorers.

Totally and relatively more of their central actions were with one hand than with the other hand or with both hands together.

C. Continuity of Direction

Associated with the ability to traverse the midline of the body and the centre of the board is the ability to maintain a directional continuity. A starting point either at the left or the right is established from which movements continue in a consecutive linear order. Alternatives are 1) to place or collect objects simultaneously, e.g. placing both cards in the two-card picture sets with both hands at once; 2) to vary the order within the sets, e.g. beginning with the middle card; 3) to deviate from a linear arrangement, e.g. placing the cards in a pyramid (as Claudia did, but only on sets 7 and 8).

The Placement and Collection ordering patterns of the 12 children are presented in the following table. Initial actions and subsequent adjustments together determined the ordering pattern of each of the six sets. Another continuity indicated in the table is collecting the cards cumulatively from the board, rather than putting them one-by-one into the box.

Table 6.2c: ORDERING PATTERNS PER SET (Task A)

		(B)	PLACEMENTS					COLLECTIONS				:	CUM
			L-->R	L<--R	S	V		L-->R	L<--R	S	V		
Polly	+	(1)	<u>6</u>	0	0	0		0	<u>6</u>	0	0	:	0
Amelia	-	(2)	1	0	0	5		3	2	0	1	:	0
Lucy	-	(2)	1	<u>5</u>	0	0		1	2	1	2	:	1
												:	
Alice	+	(1)	<u>5</u>	0	1	0		<u>6</u>	0	0	0	:	<u>6</u>
Jessica	+	(2)	2	0	1	3		0	0	2	<u>4</u>	:	<u>5</u>
Simone	-	(3)	2	1	1	2		0	0	2	<u>4</u>	:	<u>6</u>
												:	
Joan	+	(2)	3	1	0	2		3	2	0	1	:	0
Claudia	-	(2)	1	0	0	<u>5</u>		1	3	0	2	:	1
												:	
Kathryn	+	(1)	<u>6</u>	0	0	0		<u>6</u>	0	0	0	:	0
Jonathan	-	(2)	1	1	2	2		0	3	1	2	:	2
												:	
Joel	+	(1)	2	1	0	3		0	0	<u>6</u>	0	:	<u>6</u>
Samuel	+	(1)	<u>4</u>	1	0	1		<u>5</u>	0	0	1	:	1

L = left; R = right

S = simultaneous

V = varied

CUM = cumulative Collections

(B) = IHR band

n = majority of sets (4 to 6)

Other notations are the same as in the preceding two tables.

The four children who established a left or right base from

which they maintained the direction for both Placements and Collections in most (4 to 6) of the sets are all above-mean scorers. They include two perfect scorers and are all in Band 1. Progressions were from left to right with the single exception of Polly's reversed (right-to-left) Collections. No more than one set for any of them was placed or collected in a simultaneous or varied pattern. (For the other eight children, simultaneous or varied Placements or Collections totalled from three to 10 sets, with seven the median number -- also for the five below-mean scorers.) Strictly by score groups, the mean for sets placed and collected in a linear order is 70% for the above-mean scorers, versus 47% for the below-mean scorers, with the difference greater for Placements than for Collections (by 30% for Placements versus by 17% for Collections).

One other child had a totally consistent ordering pattern, for simultaneous two-handed Collections of the six sets. He (as previously indicated) is Joel, who is the other perfect scorer and the other child within Band 1. Only he and the three deaf girls collected all the cards within all or all but one of the sets cumulatively; of them, only Simone has a low score. Alice, the oldest of the children, succeeded on both measures of continuity (continuous linear movements and cumulative collections).

A contrasting group of four children neither placed and collected most sets in a continuous direction nor collected more than two sets cumulatively. They are all in Band 2.

In summary: Of the twelve children, only above-mean scorers (all in Band 1) both placed and collected the cards in the majority of sets in a complete linear progression. Also, three of the four children who collected all the cards in most sets cumulatively are above-mean scorers.

Conclusion. The asymmetries shown in the contralateral directions of reaches, in a midline handedness dominance, and in continuous linear ordering skills differentiate the

children who were successful at the sequencing tasks. The high-scoring left-handed/ambidextrous children, however, more closely resemble the lower-scoring right-handed children. Their more symmetric patterns are characterized by parallel rather than contralateral reaches, by a greater equivalence of right- and left-hand contacts at the midline, by simultaneous contacts and a varied order of placing and collecting the materials.

In Figure 6A, the mean percentages on the three measures for the right-handed children are shown separately for the above- and below-mean ASD groups. (The numbers averaged are a) the mean Placement and Collection percentage of contralateral reaches, b) the highest midline contact percentage, and c) the mean percentage of sets placed and collected in a continuous direction.) In Figure 6B, the mean of the three measures and the individual scores of each of these 10 children are plotted. (The line showing the relationship of the actions and scores is drawn through the median values, i.e. the middle at the left and the middle at the right.)

The age-adjusted scores of the 10 right-handed children correlate significantly with each of the three measures:

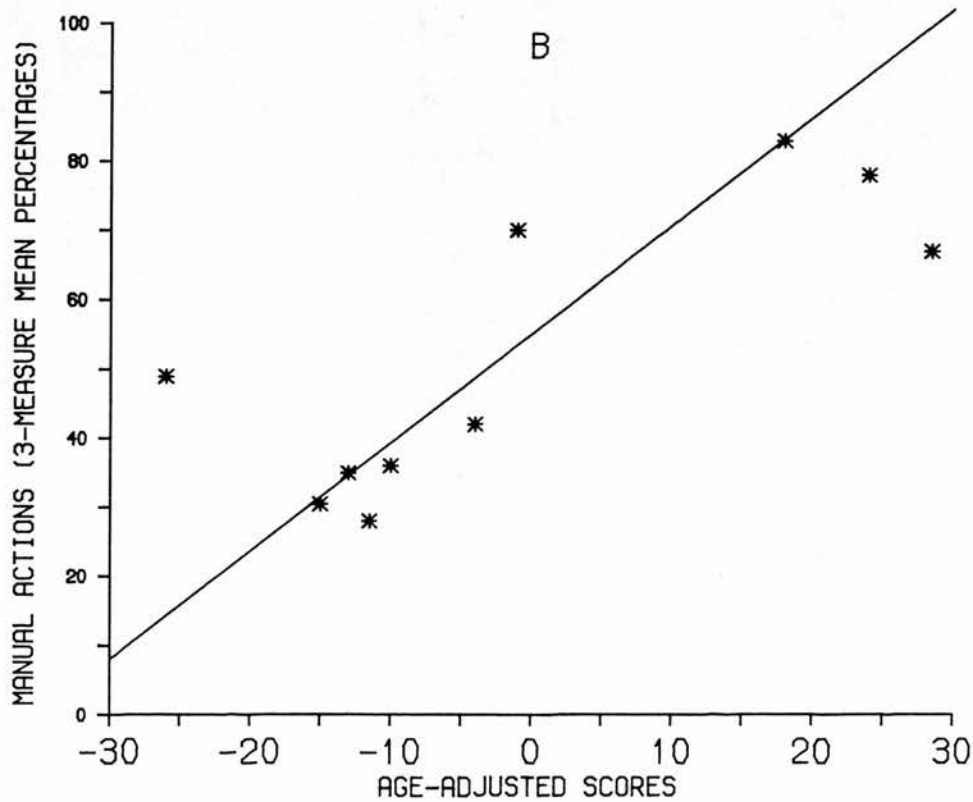
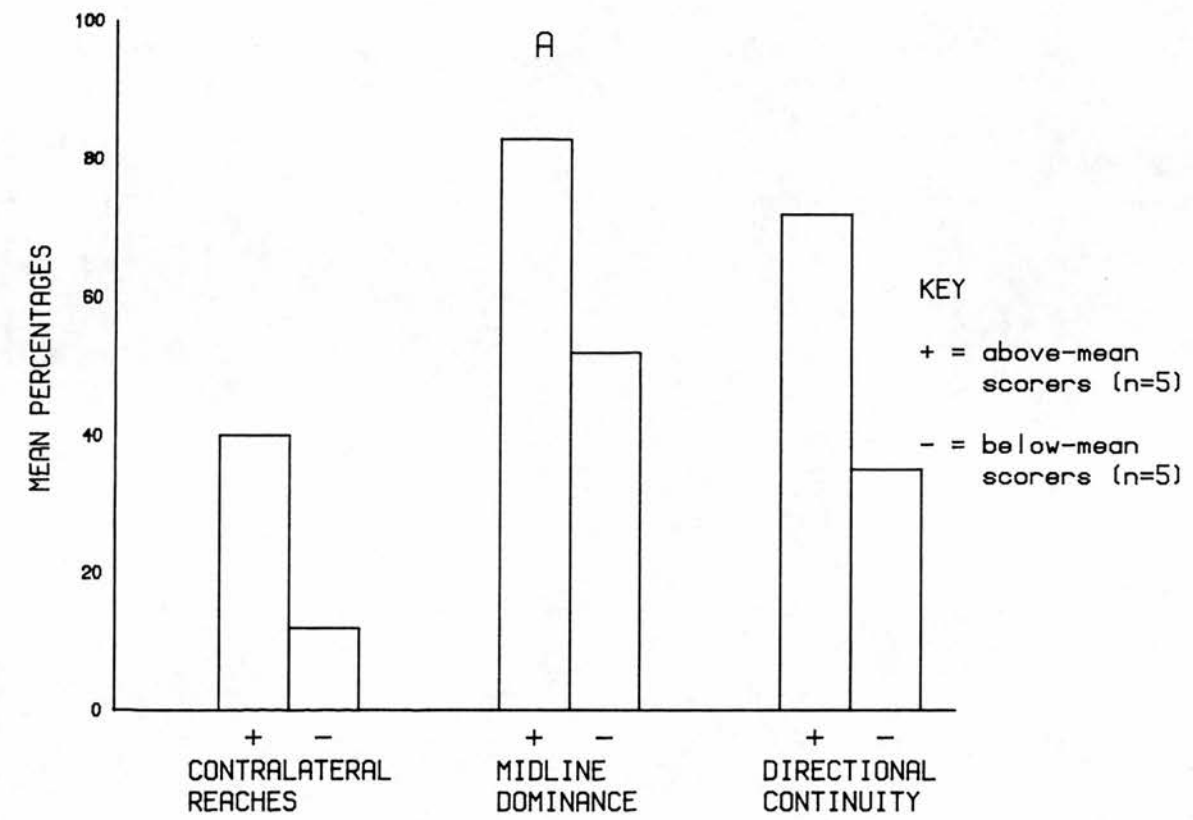
	r_s Coefficient	Significance
ASDs with contralateral reaches	.780	<.005
midline handedness dominance	.760	=.005
directional continuity	.579	<.05

three-measure means	.697	<.02

The single measure which correlates highest with the scores is contralateral reaches. The highest inter-measure correlation is between contralateral reaches and directional continuity ($r_s = .797$, $p < .005$).

The 12 children whose handedness patterns have been analysed in this section comprise but one-fifth of the total study population, and Task A is but one of the three tasks. Although the sample is small, the handedness patterns seen elucidate and corroborate the results previously reported for all the children in the study. Regardless of the samples selected or the analyses made, the same association is shown:

Figure 6: MANUAL ACTIONS OF 10 RIGHT-HANDED CHILDREN



The children's manual actions correspond to their mental abilities.

SAMPLE OF SIX CHILDREN

The six girls in the hearing-deaf dyads, and included in the sample of 12 children, were studied in greater detail. (A more complete description of their actions and their spoken/signed communications is provided in Appendix G.) As this section concludes the report of the handedness patterns of the Main Study children, the comparisons of these three dyads will summarize some of the results of the other samples and of the whole group of 60 children.

The three deaf girls who are counterparts of the three hearing girls are Alice, with Polly; Jessica, with Amelia; and Simone, with Lucy. Their scores on the three tasks are presented below for reference.

Table 6.3a: TASK SCORES OF THREE HEARING-DEAF DYADS

	<u>Task A*</u>	<u>Task B</u>	<u>Task C</u>
Polly	100%	100%	100%
Alice	100%	100%	100%
Amelia	50%	25%	0%
Jessica	40%	42%	0%
Lucy	20%	33%	0%
Simone	10%	50%	0%

*Task A scores are for the first six sets. (Sets 7 and 8 were also completed by Polly and Alice, again with perfect scores, and by Amelia, with a score of 43% on these two sets.)

Table 6.3b shows data for the Placement and Collection actions on the 11 sets of Tasks A-C for these six girls. They are a microcosmic illustration of what was seen for all the children collectively: the premium for a system of manual specialization. As all six girls are categorized as right-handers, instances of their left hand use are of particular importance. The small numbers are significant; for instance, one and zero differ by one integer but indicate either the presence or the absence of an action for all the

objects in a set.

Table 6.3b: HANDEDNESS FOR PLACEMENT (P) AND COLLECTION (C) ACTIONS
ON THE 11 SETS OF TASKS A-C

	+1		-1 Cs*	+1 and -1		- ratios			0 ratios	
	Ps	Cs		%P+C (/22)	%C (/11)	Ps	Cs	%C	Ps	Cs
Polly	3	4	4	50	73	1	5	: 83	2	0
Alice	4	5	4	59	82	0	4	: 100	1	0
Amelia	5	0	1	27	9	0	2	: 100	0	3
Jessica	2	1	0	14	9	5	2	: 29	0	2
Lucy	4	6	0	45	54	3	0	: 0	2	1
Simone	3	1	1	23	18	1	3	: 75	0	4

*None of these six children had a -1 Placement ratio. (Only 10 children in the entire study had: nine on a single Task A set, the other child on three Task A sets.)

Exclusive left-handed (-1) Collections, found to be a strong indicator of task success, are associated with the higher scores. Only the four children who have task scores of 50% or greater collected all the objects in at least one set with their left hands: Polly and Alice, both perfect scorers and the only ones in Band I, have exclusive left-handed Collections on four sets each, Amelia and Simone on one set each. The single set with a -1 Collection ratio for Amelia was on Task A and for Simone was on Task B -- the tasks with their 50% scores.⁷ Polly's exclusively left-handed Collections were on four of the five sets of Tasks B and C (all three of Task C); all of Alice's negative ratios (apart from two negligibly negative Assists) are absolutes (-1 Collections, three on Task A and one on Task C). None of the four girls who have zero scores on Task C have a -1 ratio on that task (as they haven't on any task with a score lower than 50%).

When any negative ratios, not only the absolute -1 ratios, are considered, again the four girls who have a task score of at least 50% are differentiated by having the greater proportions of negative ratios on Collections rather than on Placements:

⁷Amelia, the higher scorer of the two, combined her -1 Collection ratio with a positive Placement ratio, of .500 (and on this set the order of the cards was consecutive, but reversed: 3-2-1). Also, on set 7 of Task A, her Collection ratio was again -1, her Placement ratio again positive, at .555 (and only one card was out of order: 2-3-4-1).

from 75% to 100% ($m = 89.5\%$) for them versus of 0 and 29% ($m = 14.5\%$) for the other two girls. Therefore, for Collections, predominant use of the left-hand (i.e. negative ratios of some degree, as well as absolute negatives) was favourable, while greater right-hand use (no or fewer negatives, either absolute or relative) was not.

When *all* absolute ratios, the +1 as well as -1 ratios, are considered, it is seen that only the two perfect scorers used either hand exclusively for at least half of the 22 Placement and Collection actions (Polly for 11 and Alice for 13). Lucy, the lowest scorer, illustrates an important distinction. Although she has the most +1 ratios (10), she has no -1 ratios, and negative ratios only for *Placements*. A condition to the rule of one-hand supremacy would seem to be systematic alteration -- selective deliberation in the use of both hands without neglect of one hand.

A related measure is the range of the children's ratios (for Placements Assists, and Collections) and its association with the children's Inventory Handedness ratios and their scores. Polly and Alice have the most leftward (lowest) ratios, the widest ranges, and the highest scores. As shown below, the range of the ratios for each child declined as the IHR was more rightward; likewise, the scores of the dyads decreased.

Table 6.3c: RANGE OF RATIOS, IHRs, AND SCORES

	PAC Range	IHR (Band)	Total Score
Polly	1.282	.231 (1)	100%
Alice	.741	.385 (1)	100%
Amelia	.700	.467 (2)	25%
Jessica	.659	.500 (2)	27.3%
Lucy	.648	.692 (2)	17.7%
Simone	.603	.818 (3)	20%

Another association of the children's IHRs and scores is with the numbers of absolute (+1 and -1) ratios for Collections alone (shown in Tables 6.3b and c). Highest percentages are those of the two girls who have perfect scores and the

furthest left IHRs: Polly collected all items in 8, Alice all in 9, of the 11 sets with only one hand (for 73% and 82%, respectively). Next highest percentages are those of the two girls with the furthest *right* IHRs. Lowest percentages, then, are those of the two girls with the middle IHRs, who collected only one set each exclusively with one hand.

A contrasting measure is the number of zero ratios, which represent equal use of the right and left hands. All but two of the children's 15 zero ratios on Placements and Collections occurred on Task A, 10 of the 13 on the two-card sets. Differences between the perfect scorers and the others are in the numbers of zero ratios and in the type of contact (shown also in Table 6.3b). The four low scorers have proportionately twice as many zero ratios as have the two perfect scorers (respective means are 3 and 1.5), and three of them have zero ratios only on Collections -- the opposite of the two perfect scorers, who used both hands with equal frequency only for *Placements*. Lucy is the exception, with both Placements and Collections having zero ratios for parallel, split, movements -- left-hand contacts on the cards at her left and right-hand contacts on the cards at her right.

The final measures to be mentioned that distinguish the two perfect scorers are their transfers of the materials and their midline crosses (see Table 6.1e for the data). Polly and Alice both have a nearly equal number of transfers to their right and to their left hands. The others showed a bias, Simone with 81% more transfers to her left hand and Amelia, Lucy, and Jessica with more transfers to their right hands (83%, 75%, and 63%, respectively). By far the most midline crosses were made by Amelia: 26, versus the next highest number of seven. (Including sets 7 and 8 of Task A, her right-hand crosses total 39: 23 with her right hand and 16 with her left hand). All but two of Amelia's crosses were on Task A -- the task with her 50% score. Some of her right-hand crosses were independent, but every left-hand cross was simultaneous with a right-hand cross, when she exchanged two cards. Polly and Alice are the only other children who

crossed their midline with both hands -- but only once simultaneously (when Alice made a tentative middle two-card exchange). When all the Task A sets that were completed are included, Alice's other two left-hand crosses and all seven of her right-hand crosses were independent movements; Polly's single-handed movements across her midline total 13 (five right and eight left). Simone and Jessica made a midline cross only once each (Simone with her right hand and Jessica with her left hand); Lucy's six crosses were all with her right hand.

SUMMARY

Most of the handedness differences between the children in these samples would seem to relate more to task success than to hearing status. All together, their handedness patterns identify characteristics associated with task success and failure. Of major importance is the ability to use each hand independently, e.g. to cross the body's midline with either hand, and to coordinate actions of the two hands. Such manual specialization would appear to be evidence of, to be dependent upon and in accordance with an internal regulatory mechanism -- a mental system that functions with both specialization and integration. Indicative of failure is the neglect of one hand or a guddle of both hands. Information available in the different patterns is evidence that there is power in the hands of these children.

CHAPTER 7

LANGUAGE

When children speak, they speak their minds.

Anonymous

Information about the sequencing task scores and the handedness ratios and patterns is incomplete without a description of the other means by which the children communicated their understanding. The children's narratives and incidental comments were considered *not* incidental but relevant and necessary to our understanding of what they were thinking and feeling. It seemed important to see whether their words and signs might be congruent with and complement -- or contradict -- their actions.

As personality becomes more integrated and unified, the manual and lingual expressions cannot help but become more consistent with one another. (Allport and Vernon 1933, pp. 19-20)

The language reported in this chapter is what children in the Preliminary and Main Studies said and signed while they were doing the sequencing tasks. Descriptions of their drawings are included, to show how in this way also they expressed their thoughts and what was important to them.

Concerning the transcriptions of the children's narratives, some difficulties should be mentioned. First, in addition to the general difficulty of accurately transcribing speech from tape recordings, there is the notorious difficulty of deciphering the speech of children -- most especially the speech, as well as the signing, of deaf children.

A child may muffle his speech deliberately and approximate a pronunciation when he is uncertain of what is correct (Ann Henderson, personal communication) and may reiterate words while deciding what to say next. He may have a speech impediment, sometimes ordinary immature enunciations, or

omissions and distortions because of a hearing impairment. Slurs, elisions, ellipses, phoneme substitutions, and speech repairs further confound comprehension and the accuracy of translations. For example, whether 'a', 'uh', or 'the' was said and whether a simple 'broke it', an over-generalized 'broked', or the more sophisticated construction 'broken' was intended is very difficult to determine, especially because the children commonly alternated such forms within their narrations (and often spoke with fingers in their mouths).

Secondly, there are the ambiguities of spoken language -- even when there are contextual clues. The following are examples of homophone confusions.

Jonathan's comment about the last card of a picture set could have been either "That door is ready" or "That door is redly". (The door had been painted so was ready for use, and it was then 'reddish' -- 'redly' in Scottish.)

Amelia's lisped question was either "Who's that?" or "Whose's that?", and a statement was either "Fishy dead" or "Fish he dead."

Jean may have been reporting actions in *Simon Says* cards or indicating compliance or refusal when she spoke the words 'eye/aye' and 'nose/no'.¹

In an attempt to avoid mistakes, underestimations, or second-guesses of what the children said and signed, the speech therapist at one of the nurseries, classroom and peripetic teachers, parents, and Scottish colleagues were consulted when the transcriptions were made. Unintelligible segments (...) and unspoken additions ([]) are indicated in

¹Instead of confusing the transcriber, a sign analogy to a homophone actually clarified the confusion of another deaf child about the name of a colour. Patrick's name sign is almost exactly the same as the local sign for 'white' -- but while he was placing a white shape, he simultaneously voiced 'p'.

the quotations.²

NARRATIONS

As an introduction to how some children described the events in the picture-card series, the narrations of the three cards in the first test set are presented below. They were given by the eight Preliminary Study children who were re-tested approximately one year later. (Numbers in brackets indicate the cards commented on when not in the correct 1-2-3 order.)

Hearing children:

Judy (4:11)

(5:8)

Somebody's felled. [2]
She's back on. She went back on. [1]
She's going to hospital.
And there she's went into hospital
and got a bandage on.

First she was on.
And then she fell.
Then she had to go to the hospital.

Douglas (4:11)

(5:8)

That, that, that wee girl's swinging
on the swing,
but then next she fell off.
She had a plaster on and had to have
an injection -- some plaster on 't
-- um, look.

Well, some -- um, a little boy is
swinging on the swing;
then he falls off;
then his mommy's putting a little,
a plaster on it.

Calum (5:0)

(5:9)

She's on the swing
and she fell off
and had to get her arm bandaged.

She's swinging on the swing
and she falls off
and she gets a band-- she gets a
bandage on her arm where she hurt it.

Fiona (5:3)

(6:0)

She's swinging on the swing.
She fell off the swing.
And then she's getting her arm
bandaged in the hospital.

She's swinging on the swing;
then she fell off;
then she has to get her arm bandaged.

Deaf children:

Natasha (3:9)

(4:11)

Fall, girl. [2]
Swing. [1]
Hurt.

Swing, play.
Swing, fall.
Bandage.

²In addition to notes taken during the testing, transcriptions of the children's communications were made from the videotapes: of 36 children (22 hearing and 14 deaf children) in the Main Study while they were doing Task A, of two of them also while doing Task B or Task C, and of 25 (13 hearing and 12 deaf children) during all three tasks. Complete transcriptions were made for 12 children in the Preliminary Study, including those who were later tested on all the tasks of both studies; partial transcriptions were made of the others' words and hand movements.

Simon (4:6)

Oh!

...make it better. [3]

He swings. [1]

And he went like that [gesture];
he fell.

(5:8)

Somebody was running,
and then she fell,

and then she had to go to the doctor.

Patrick (4:9)

Swing.

Fall.

Hurt.

(5:11)

Wow! Swing!

First. [3]

Hurt. Fall. Hurt. [2]

Keith (4:9)

Swing.

Fall.

Hurt arm, bandage.

(5:11)

Swing.

Fall.

Bandage.

Three of these children (Calum, Fiona, and Keith) had perfect scores on Task A when they were first tested, and another (Douglas) scored above the mean for the 20 children in the study. Those four children again later placed and commented on the cards of this set in the correct order, and three others (Judy, Natasha, and Simon) later sequenced these cards correctly. Yet when the first and second narratives are compared, both a change and a constancy can be seen.

1. The later narratives tend to be more connected, as when 'and' and 'then' are added and when all three events are reported in the same (present) tense.
2. There are individual continuities in what was first and later said or said and signed.

The consistency of the hand movements of each of these eight children at the two times of testing (see Chapter 2) has a counterpart in the similarity of the constructions used and the words chosen. For example, Judy twice refers to the hospital, and continued to end a sentence with 'on'; only Douglas used the word 'plaster' -- and he repeated it the second time; Calum and Fiona repeat the specific of 'getting her arm bandaged'. One hearing child but three deaf children comment on 'hurt'.

Similar expressions in the other three Task A sets that were repeated include the following examples.

Calum: "That's whole." --> "A whole apple."
 Douglas: "Ane none apple." --> "None."
 Keith: "Nothing." --> "Nothing."
 Fiona: "She's got a kite." --> "Well, the boy's got a kite,
 "She's flying the kite." and he's flying it,
 "The kite's broken." and he -- he's thinking, 'Oh, dear --
 my kite's stuck up in a tree!'"
 Judy: "And it does fall in the tree again." --> "Then it fell in the tree."
 Simon: "And then it went up and the wind blew it and then it falled. [2] And then it break." --> "Then he started wind it, and then it went on top of a tree and it burst."
 Natasha: "Fly." --> "Hold-kite [mime]."
 "Break." --> "Fly-kite [mime]."
 "Break." --> "Break."
 Fiona: "The man's painting it." --> "Then the man's painting it."
 Patrick: "Red." --> "Paint red."

There were also many individual repetitions in the comments these children made while they were doing the other tasks again. These echoes, though, along with the children's improved sequencing abilities and the increased specialization of their hand movements, show development of their linguistic skills.

Developmental progressions can be seen when the comments of younger and older children in the studies are compared. For these descriptions, the children were divided by scores rather than by chronological age. Those whose *total* scores on the sequencing tasks presented to them are below the mean (56.5% in both studies) are categorized as 'younger' children, those scoring above the mean as 'older' children. (Included with the younger children's comments about the Task A picture cards are those of some of the categorically older children if their scores on this task were below the mean.)

Younger Children

How some of the younger children interpreted the tasks was made clear by what they said and how they spoke. To them, the picture cards were not A Test of Sequencing Ability, but rather a chance to tell a story and play a game. For instance, Murdo began his descriptions with "Once upon a time...". Penelope's stories had both a beginning and a

conclusion: "One day... and that was the end."³ Fiona had replied that the kind of story the apple pictures might tell was "Sleeping Beauty", but Jonathan's fairy tale about the apple resembles Goldilocks more than Snow White: "Somebody's eaten a bite of it, and that one's eaten all up!"

Adventure continued in the next set for Jonathan: "Somebody's chopping the arm off!" (Nevertheless, his sensible reply to the prompted "And then what happens?" was "Not have a arm left.") A 'falling' theme appeared in five of the eight sets: "A girl sw-- fell off on the hook ... Um, she fell off. Um, somebody, nobody fell off of that"; "The rope's fell off"; "Something fell off the bus. ...the big, big steps, and he f--"; "Now the tree fell down"; "They had a leg falled off." (Ernest's theme repetition was 'knock': The boy, the cat, and the tree got knocked over -- the last when "it knocked it down.") Throughout, Jonathan narrated the stories in a sing-song voice, and he established rules: "I'll tell ya it. ... Don't start it [the timer] yet. NOW start it." In the last set, of the cat coming in and going out, the game became one of discarding the picture cards: "That goes out, that goes out, and that goes out. It's finished."⁴

Most younger children commented on the pictures one-by-one as each card was turned over. They seldom altered either their initial placements or their original versions in the concluding narratives. Comments were often about single details and events in isolation. If connected, the events

³Another left-handed girl also ended her descriptions of pictures she drew in the nursery: After Zoe had named what she had drawn, she would conclude, "That's all. ...Nothing more. ...Nothing else."

⁴Simon also played a card game during the re-testing. When he detected a card out of order, he said, "You didn't know that, didn't you?" -- or if in order, he said, "You did that one right!" Ultimately, he decided, "You're doing all right and I win." He did win: His re-test score improved the most -- from 17% to 100%. (Fiona gave me some credit for the trick shape, saying, "Good -- but not good enough...") The turn-taking part of a game was important to Mhairi (whose score only on Task A is below the mean): After she had completed set 7 (describing the events in the reverse, 4-3-2-1, order), she suggested, "Now you has a try. Would you like a try?"

were explained in the order of their placements; i.e., the narrative accommodated the order of the cards, but the order of the cards was left unchanged.

Examples include Judy's explanations (above): The girl is back on the swing and the new kite fell in the tree again. Sean, and others, had a simple explanation for the second kite-flying picture in the last position: "It's fixed." To Rhona (who scored 30% on Task A), the first tree -- placed at the left but commented on second -- also was 'fixed'; to Martin, the tree declared to be "Broke, dead" was "up again". Charles' restitution was more elaborate: "I think he'll have to lift this tree back on and put all the bits and pieces back." In the cat and fish series, when the picture of the cat entering the room was placed after others, Beth's explanation became "Runs away", Ernest's was "He's running back through", and Ellen's was "Running away -- frightened."

By their remarks or points and quizzical expressions, some children showed concern about the cut-off head in the apple picture, the bodyless hand that is painting the door, the bus that is 'broken', the hinges that weren't painted, as well as about missing symbols in the corners of some cards -- or about the presence of some (e.g. Martin: "There's a mud on there!"). It was the marks indicating that the boy was running and the ball rolling that bothered Alan: He tried to scratch them off. Susannah noted there is writing on the back of some but not other cards: "Look -- hasn't got any stories on back!" (To the suggestion that stories could be made up, she exclaimed, "But how can we?" That she and others could is reported later.)

Often by looking at only one picture at a time, children's identifications were confused. The burst balloon was scrutinized from several angles by Susannah, who muttered, "Hat, and a bug, falling down into it. No, It's a piece of paper. Or a money. Or a hat. Or a bug." Jonathan just sang, "All the washing flowed away, and all the washing's

flowed away."⁵ Within single pictures, there were confusions: Hamish identified the apple in the first picture of the demonstraton set correctly but in the next picture called it a peach. Susannah first said "Swing one" and "She fell off the swing" but later, after she had rearranged the pictures correctly, she instead said, "The, the kid was playing on the slide." (Amelia's name for the swing, reported in Appendix G, was 'box'; Judy at first called the empty swing a kite; Liam, an older child, identified the poles as "the climbing".) Alternative names for the nail in the balloon set were a needle, a knife, "one of the woodwork nails" (a specification of Lawrence), and "what he, he blows the balloon up" (Claudia's original identification). To Penelope, the bubbles in the fish bowl were 'babies'.⁶

Indications that each picture was seen to be discrete and unrelated to the other pictures are found in subject (noun and pronoun) changes. Rhona's spontaneous comments about the swing-set pictures began with the third card: "This one -- that one, that wee girl goes to school." About the next two, she said, "That one, he went to the swings. That one, he fell off." Her differentiation persisted when the cards were sequenced correctly for her: "He goes on the swing. Fell off. She went to school." Two different boys and two different balloons are suggested in her comments "'s a wee boy got his

⁵This picture posed problems for others as well. Until Duncan looked at the picture of the blown-up balloon, he seemed to think the pieces were part of camping: "House. Bed tree, sleep bed. Nail[-point] pound-in-peg [mime]." Even with the other picture, Richard thought they were pictures of apples: "That's -- all skin's on it" and "All skin's off it."

⁶The most common misidentification of all the children was of the sex of people in the pictures: To many, the person on the swing was a boy and the one with the kite was a girl. The woman bandaging the child's arm was usually named 'Mommy', but Zoe thought her the teacher, Mhairi chose to call her a nurse, and Sean called both people 'children'. Jessica named the person chopping the tree both 'man' and 'Daddy'. Names also were invented for the shapes: Circles were often called 'round' -- but also 'bubble' and 'snowman', triangles simply 'angle' by one child and 'a Christmas tree' by another; a rectangle was 'a straight-up one' to Charles. The purple shapes were also called 'brown' and 'pink', and yellow to Angus was 'a kind of lemon colour'.

kite, and that's a wee boy looking at the tree and his kite. That, that's a balloon what hasn't burst, and that one has." (When asked if it were the same balloon that something happened to, she pointed to the blown-up balloon, at the right, replying, "This one later" then pointed to the burst balloon saying, "One's first.")

There are similar clues in Claudia's descriptions: "Here the door is all yellow, and this door all painted." Perhaps because she is bilingual and may have substituted 'again' for 'also', there is an ambiguity in the numbers of boys and kites she described.

#1: "He's lucky, because it -- his, his, his kite didn't blow in in the tree."

#2: "He's lucky again, because his kite didn't go in in in the tree again."

However, in set 7, her narration of the second card began with "This man..." and of the first card with "That man...". When queried, she said that the person in these two cards was the same, and that the person in the last two cards was the same.

Similarities. "Same" comments -- whether in words, signs, or gestures -- were frequent. Samuel pointed out the similarity of the tires and the ball, and William rolled a toy bus alongside the bus-boarding series. Similes in Beth's comments about the circles were "Look! That's like a man. That's round -- the same as the table!" While to Amelia the shapes within white circles were a 'sandwich', Lawrence thought the shapes in a pile "look like garlic sausage, 'cause garlic sausage is round." In another analogy, he had the right idea (but meant 'triangle') when he pointed out half of a square and said, "So, know something? That rectangle is the same as -- Yes!" When something pictured resembled something in the children's experiences, that is how it was named: To Amelia, the bus-stop scene was 'High Street'; to Shelagh, a building in the Madeline story was 'Edinburgh Castle'.

Personifications, with objects treated like people, were seen in Jessica's pretend play with the circus cutouts and in

Amelia's labelling of squares as 'a wee Poppa one'. Shelagh also made up stories about the *shapes*: "The man and her was married, and her was over here..." Putting shapes back into an envelope, Angus said, "In we go!", and Tarini wagged her finger at the shapes in a bulging envelope, signing "Sit, you!" Charles substituted himself for people in the pictures: "I'm cutting it"; "Once I was getting up, then I got the policeman to come and get me from the road, but I got run over by that"; "I touched my paw into the water..."

Anthropomorphism was suggested in some descriptions. For instance, Amelia attributed feelings to the sky: "She wanted to put it [the kite] on the tree, but the sky didn't want to be..." After saying, "S-- she, the cat, thinks he will try to drink the fishy if he want to", she added, "and the cat's tail wanted to fall off." Perhaps Mhairi was just attempting passive constructions when she said, "The apple took a bit of itself" and "The needle burst the balloon by itself."

The younger children, and particularly deaf children, not only described actions but also added animations. Alan is one who activated the cards, having the people in the queue enter the bus and the siren spin around, adding "Brrrr" sound effects as he drove it away. Contacting the cards, he helped bandage the girl's arm, pierced the balloon, rocked the boy in the hospital bed, and when signing "Break!", he fell down on the table, his body becoming the tree. (Older deaf children suggested interim actions: Both Duncan and Alice mimed the actions of lifting the man from the road into the ambulance, and she added "leave, tea, finish" to explain the paint bucket but no person in the first picture about the door.)

With signs, the deaf children would express a simultaneous 'everything at once' possibility. Sign 'agglutination' (Schein 1984) is particularly evident in Jessica's narratives. One (reported in Appendix G) was a combination of elements in the signs for 'door', 'paint', and 'finish' that were modified into a single sign summation that could be translated as "Finished-painting-the-door."

The 'hurt' comments of deaf children quoted above are typical of the emotions interjected in their narratives. "Sore-arm, shame!" Jessica signed; "Sad" is what Daniel signed about both the tree and the boy with the kite; "Sorry-you" was Duncan's comment about the boy lying in the road and "Hurt, cry" about when he was in the hospital; Bruce signed, "Poor fish." Also typical were repetitions of "good" and "bad". Intensifiers were used in some exclamations of hearing children: "very sad" by Mhairi, "very hard" and "long, long" by Susannah, "really big" by Lawrence.

Other inferences and commentaries (not just comments) were made by younger children -- but mostly those who scored above the mean on Task A (i.e. at least 50%), and they were mostly about single pictures. For example, after saying, "and the tree dropped down", Susannah added, "and it's going to roll down the road." She also added her opinion of "the tree broken down": "I think that's stupid" -- and of the cat: "Broken it. Spilled it as well. Stupid."

Murdo's additions were that the swing was in "the park", the painted door was that of a "garage", the boy with the kite was "an English boy", and the cat was "with its master". (Although he called the wood chips "some, a few crumbs", he identified the man as "a woodchopper".) He speculated that the boy with the ball "stayed at hostable for a week -- 'til Christmas." (When queried, he replied, "No, he missed Christmas, didn't miss New Year's.")⁷ Murdo's other explanations were about the bus stop, first about the blank sign: "Oh, yes, it's on the other side!" and then about the long queue: The bus had run out of petrol. Claudia also had an explanation for one of "these three" in the queue: "Maybe he going to to the train, um ...going to to see maybe a a

⁷Alice, too, was adamant about the hospital stay. After she had signed what was happening in that last card -- "Then bed stay two week, because rest, sore-arm, crash" -- and was asked, "Not three weeks?", her reply was "No. Yes, two."

auntie." She also verbalized an anticipation. Seeing only the first card of the last set, she perceived the plot: "The cat's coming in. I think he's going to get the, the -- he's going to eat the the fish." (Nevertheless, she made symmetrical -- not sequential -- patterns when she arranged the five cards.)

Differentiations. While various expressions of similarities were common among most of the younger children, the language of some others is more characterized by dichotomies. When these children looked at the cards in the series -- but placed in an incorrect sequential order, their comments were about what they detected to be 'different'.⁸ Most of the following examples are of Lucy's speech because they are typical and almost identical to the expressions of other younger children.

As reported in Chapter 6 and Appendix G, Lucy's handedness patterns as well as speech showed differentiations. She tended to use each hand independently, her right hand dominantly, and to speak in absolute terms. Among her elicited picture-card descriptions, the following antonymous sentence structures appeared.

"A apple; a apple not eaten; eaten."

"Somebody's getting out; em, someone's out; and in."

"Ah ha! Cut down, and that one not cut down."

A spontaneous narrative about the personified family-member clowns was "This is Robert playing with her, and Barbara not playing." Oppositional comments include "Being naughty" (about the girl having her arm bandaged) and "Nice one" (about the smallest clown and a penguin in a story recounted). Some speech errors were antonym substitutions, such as 'out' in the above sentence about the woman who was getting *into* the bus. Also in this description, although there are four people

⁸Differences are reported to be perceived later than similarities, i.e. with one name given to several different objects that are within a same category, and with comments about 'same' and 'not same' preceding comments about what is different. See, for example, Nelson (1986) about how children's scripts are based on, and 'scaffolded' from, things that are similar and familiar.)

'out', her subject is singular. In her question "And what's these ones?", the subject is plural but the verb is singular. Nor is there agreement in another question: "Why play that ones again?"

Lucy's dialogues during the 35 minutes of testing contained many repetitions of 'one' and 'ones'. Combinations were 'that one', 'this one', and 'these ones' but were never of 'one(s)' with the distal plural, 'those'.⁹ A proximal to distal progression was seen also in Lucy's arrangements of the materials, which were outwards from the centre. Thus, in her speech and movements, the singular and the proximal predominated.

Also to be noted about the sentences of Lucy and others is their use of 'and': to connect oppositions ('is' versus 'is not' in the above sentences) or contrasts, e.g. of actions in Lucy's description "That one's swinging, and that one's running" and in Kathryn's "They're getting into bus, and they're waiting." Different uses of 'and' will be seen in the narratives of older children.

Another distinction of the children who tended to use 'either-or' constructions is the clarity of their speech. They did not lisp or substitute central sounds, such as 'w' for 'r' or 'f' for 'th'. About the two children mentioned above, Kathryn was referred to a speech therapist because her enunciation was thought to be too precise, and Lucy was the only child in the study who referred explicitly to speech, criticizing my pronunciation of 'box': "The 'bok' -- why speak like that?" (The other younger children merrily repeated my phrases and signs, like refrains in songs.)

⁹In a discussion of deixis, Garvey (1984, p. 82) mentions the perceptual salience of certain terms, saying, "there is some tendency for the term most closely associated with the speaker's position and own immediacy to be acquired first."

Discussion. It is interesting that although the cards are static, all the children, including the very youngest, interpreted actions in them. They did not simply label objects. (Even the blown-up balloon Claudia said "flew away".) The hearing and oral deaf children used verb affixes (e.g. '-ing'), and the deaf children who signed indicated actions in the movement of their signs and in their mimes. Perhaps these action interpretations -- and the reincarnation of the boy in the road and the tree -- have been influenced by cartoons, or maybe they are simply expressions of things special to children, such as their need for activity, their feelings of omnipotence, and their belief that much in the world is magic (Fraiberg 1959).

Older Children

Often the same words used by the younger children were used by the children who were successful at the sequencing tasks. Differences, however, can be detected in their sentences: in what they said and what they spoke about.

In contrast to the insignificant details noted by the younger children, relevant details were noticed by the older children. Several scrutinized the pictures on the lid of the box. That four swing-set pictures are illustrated caused Joel to say, "Only -- but, but there's more!" and Scott said, "There's meant to be more -- look!" When "First, second, and third" had been signed about the apple series, Jeremy's reply was, "Four, five, six!" Also, after the six balls were sequenced, he pointed to the empty space at the end of the table and grinned as he looked under the table for more. Simon had a similar reaction when he saw there was space for more repetitions of the shape patterns: "You've got some missing, eh?" Another astute observation was shown when Douglas saw the *Simon Says* cards: He repeated his 'raise your arm' imitation, this time pretending to pinch a morsel of food for a bird on his hat too.

Most importantly, the older children expressed an awareness of more complex relationships. A cause-and-effect relationship is seen in Duncan's signed commentaries: "Fall, hurt head, hurt; fall, swing-high-round-and-round. Better swing-slowly-low." ("Run-slowly" was also his solution to avoid being hit by a car.) In Polly's parallel sentences "That's the balloon and that's the needle", the 'and' simply connects the two objects shown in the picture. However, these two objects have an actual cause-and-effect relationship, which she explains in her next sentence, this time with the 'and' relating two events: "Then somebody poked the balloon and it popped." (The consequent action was mimed with both hands.)

A temporal relationship is shown in what Polly says about the door:

Um, there the door is, and then there the brush and that, and the the brush and the paint pot, and then, and then the door was to be cleaned; then the man had cleaned it; and then the door all painted.

Polly continued to locate where actions occur, but with points and repetitions of 'there' instead of the more ambiguous "[In] that one" phrase of the younger children. She also offers a solution about the kite sequence that is an interpretation beyond what is shown in the three cards (versus an inference from a single card):

Well, there, there he's wanting to fly a kite. There it's flying ... and got caught, and there it's broken. They can get it down like that [pinching the kite from the tree].

Duncan's conclusion about the kite also had a continuation:

Fall, break -- break, tree. Climb-up, girl climb-up, get-it down. Fix. [Nod]

Alice's final suggestion was "Fly kite." Jeremy, however, used only gestures as he spontaneously repaired the kite himself, pretending to tie the two broken ends together.

A 'mean length of utterance' measure would have been deceptive. Jimmy (chronologically the oldest deaf boy in the studies but categorically among the younger children) did use

only two signs when he signed "Paint; key; paint" (with the centre card in a horizontal position). However, there is a verbal economy in how other deaf children accurately described the changes in what happened to the door: Jeremy signed, "Door yellow; yellow, red; red", and Shona said, "It is yellow; red and yellow; all red."

The passive construction of 'get' with a verb that is seen in early stages of language development (Menyuk 1971) was used by some younger children when saying that the boy "got run over". This and two other passive forms appeared in Liam's narrations: "The bowl was broken" and "The boy's waken up by a ambulance."¹⁰ Nathan (chronologically the oldest child in the Main Study and by scores among the older children) repeated a 'going to' structure to mark the future tense in his narrations (consistently omitting the subject): "Going to fly a kite" and "Going to get the fish; walking over to get the fish; going to get the f-- to get the fish on the table."

Another older boy, Jasper, used 'a' and 'the' differentially, introducing a subject with the indefinite article and later, referring to it, the definite article: "People waiting for a bus. ...People on the bus" and "A balloon, and a nail broke the balloon."

Zoe, as well as Fiona (above), used direct discourse in her narrative of the same episode: "Well, he first came and thought, 'Ah, well, I'll fly a kite.' So he flied a kite, and then it went on the tree." (When Jessica reported what someone said, it in a digressionary conversation about the dog cutouts' being scolded and sent to bed.)

¹⁰Although in the latter sentence Liam created a continuity between the two cards, and between the first two events -- "and is playing football on the road, and he got run over", he kept the cards in that 4-3-1-2 order. (He made no other mistake on the eight sets of Task A, no mistakes on Task C, and on Task B, the misplaced #3 clown and dog cutouts were his only uncorrected errors. He did, however, collect the set 7 cards in the correct first to last order, and removed the misplaced clown first, then inserted all the clowns into the envelope in a correct size sequence.)

The word 'first' in Zoe's sentence quoted above (and in all her narrations) was typically included in the comments of the older children while they were arranging the pictures, the clown cutouts, and the shapes. They seemed to be not merely imitating a word they had heard, or a sign they had seen, but to be cuing themselves about the sequential order of the objects. Angus, for example, accompanied his placements of one picture set with the instructions, "That goes first; that one goes next; that one goes after." About a picture in another set, he deduced, "That must go first." Lesley decided one dog should go "behind" a smaller one. Joel's prompts to himself about the shapes in each set included the comments, "And now, um, yes -- cir-- no, circle's in the middle ... Um, start from this ... and then triangle ... Now circle? Yes, circle's last."¹¹

Most of the older children used relative terms when deciding the order of the size cutouts. While younger children would label an object as 'the baby one' or as 'little' or 'big', the older children would use comparatives and superlatives -- but not without errors. About three clowns, Joel said, "and a bit more bigger." Angus correctly identified "the very smallest, the second smallest" and "the second long one" but then declared one "the most largest!" In contrast to the common 'doggie' diminutive of younger children, Fiona called the smallest dog 'puppy'. Elspeth is one who used the general term 'size' and a relative adjective-noun combination, saying, "Smallest dog."

Other sophisticated words were chosen. Scott had the dog in the Madeline story not running but "scampering, scampering

¹¹What the older children did repeat were actions that had been demonstrated. Jeremy followed the most examples: making comparative measurements of the circus objects and flipping the pile of dogs to check the size sequence; maintaining a space in between the repeated shape patterns and collecting the shapes in all the sets into piles of three that adhered to the pattern order (i.e. not by the same colour, as in the collections of the younger children, or by shape when all the shapes were the same colour -- the choice of some older children).

away" (after he asserted that Madeline might drown "when the tide comes in"). Polly's cat was "peeping at the fish, ...coming right in, ...dipping her paw in it." Liam's specification about the kite was that "...the rope snapped."

Two of the deaf children whose scores are the highest of the children in both studies spontaneously used several attributes when identifying the shapes: About those in one set, Keith signed, "Green triangle small, white big circle, medium blue square." Alice's signs for the last set (commented on in Appendix G) were "Square, small purple; triangle, purple big; purple big round."

A last narration to be mentioned is Alice's of the last picture set. Her way of simultaneously combining signs made with each hand and mimes could be translated as 'while' phrases.

When cat see fish, see [stare continuing through this and the next sentence], like fish eat. Then creep-in [determined expression with her mouth added and the advance emphasized by her moving her body forward], like fish [her tongue licking her lip and her left hand held in a paw position]. Then jump on table. Paw-in [mime] water fish [both words signed at the same time, the 'fish' under the 'water']. Then spill, fall. Fish eat -- [head shaken with her following correction] cat eat fish. No fish.

DRAWINGS

The photographs that are the frontispiece of the thesis are of the fingerpaintings made by two of my first students, both severely multihandicapped deaf children, when they were five years old. The line in the middle of the one was caused by the paper's having been folded when transported, but it emphasizes the Rorschach-like image created by the children's movements. The divisions and the symmetries show that each hand functioned in a similar way but within a separate ipsilateral space (thus blending only the vertical yellow-green and purple). Neither Mary nor Michael spoke, yet with the paints they have communicated something about their mental capacities.

The pictures reproduced at the end of the thesis were drawn by another five-year-old child (a hearing boy at a school in Edinburgh who participated in another research project). Daniel first drew the apple core, then the other two apples. After sequencing them, he decided to draw the trees, and explained their cyclical sequence as well. They illustrate another extreme in children's abilities.

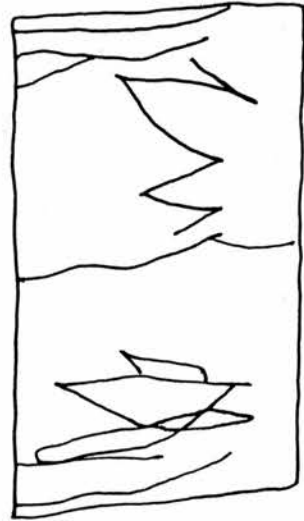
The following drawings were made with the chalk and slate during the Handedness-Sidedness Inventory. (All but the last two reproductions were traced from photographs taken from the videotapes.)¹² The subjects chosen by the children are shown below.

Table 7: SUBJECTS OF DRAWINGS

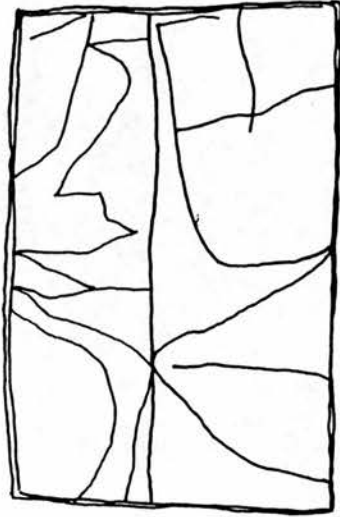
	Hearing children	Deaf children	:	Total
Person	15	4	:	19
Face	4	2	:	6
House	6	4	:	10
Animal	6	2	:	8
Design/scribble	4	9	:	13
Other	2	2	:	4

Person and face. Fifteen children identified the person or the face drawn. Six were declared to be self-portraits. (Duncan drew his face after he had drawn the face of the child tested with him -- his own much smaller and later scribbled out.) Two boys drew their dads, two of the girls their mothers and the other two their sisters (one her twin). Three were identified as men -- 'silly man' and 'a superman' by two boys working together. Names were added to four of the drawings, one within a sentence (illustrated above) and another along with a skyscape (of stars, rain, a rainbow, and

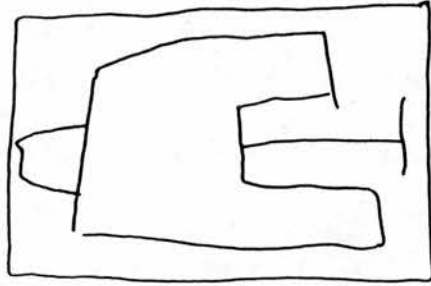
¹²There are records (notes or videotapes) of the drawings of 60 children (37 hearing and 23 deaf children): the eight Preliminary Study children who, when re-tested, completed the HSI plus 52 of the Main Study children. (Information for seven hearing and one deaf child in the Main Study is only about their handedness while they were drawing the pictures.)



Sean (3:0)



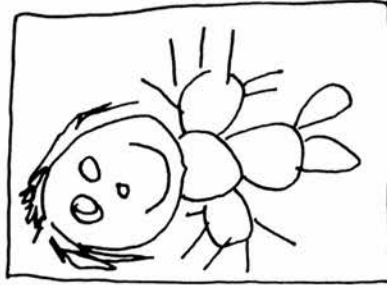
Heather (3:9)



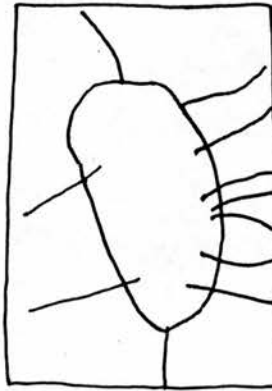
Ronald (4:1)



Lesley (4:2)



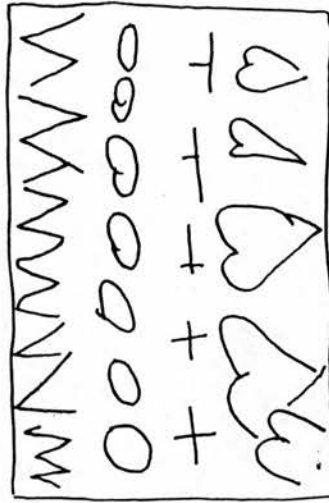
Tessa (4:2)



Murdo (4:9)



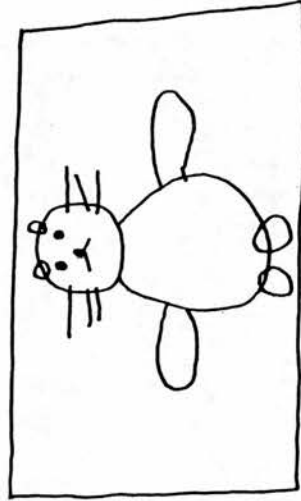
Megan (4:9)



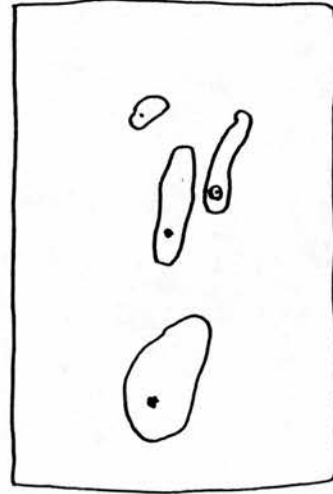
Natasha (4:11)



Gayle (6:8)



Alice (7:0)



Jimmy (7:6)

a cloud).

House. Megan's addition of grass (above) was exceptional: No other child drew grass -- or a tree or a flower.¹³ Additions to the houses that were commented on include a garage, roofs, chimneys, a letter box, door number, doorbell, knocker, curtains, a pet budgie in a window, and a bird in the sky.

Animals. Cats were drawn by three children. Other animals were said to be a bee, a snapper, and 'a huge elephant'. Two boys, working together, drew spiders. The original spider (Murdo's, shown above) began as an elephant: "It's got two trunks. No, I'm going to draw a spider." When asked where the web was, he replied, with a gesture and intonation that were theatrical, "It's invisible!" (The other boy copied the explanation also.)

Designs/scribbles. While some drawings were clearly meant to be designs (e.g. Natasha's, above), others that were not identified, or identifiable, are included in this category. Some of the scribbles might have been writing approximations, but since there are similarities in the objects that were named (e.g. Murdo's spider and Tessa's arm and fingers), perhaps the children had other intentions. The reproduced drawing of Sean (the youngest child in the study, and one who had a squint) began with the central line, the first part drawn up and the second part down. He next drew the lines at the right and last those at the left. The next youngest child's drawing that is shown, that of Heather, has similar features, although her strong central line is horizontal, and the other lines connect with it. The drawing of the oldest child (Jimmy) consisted of only the figure at the left; the other objects were added when he was asked "More?" (Perhaps it should be classified as 'animal', if representing embryonic

¹³This 2% incidence, however, is greater than the .8% for a 'vegetation' theme Kellogg (1969) has reported in the drawings of children between the ages of three and five.

polliwogs, rather than as a Paisley-type design.)

Other. One child's drawing clearly was writing: his name. Ronald's helicopter (above) and another child's bus were the only vehicles drawn. One other child drew a hopscotch (twice).

Comments. The 12 left-handed/ambidextrous children all drew identifiable objects. However, how four of them drew was unusual. Both Lesley's (mum's) face and Tessa's person were not drawn as they are shown above: They were drawn sideways, beginning at the right. Penelope's person and Joel's additions were drawn upside down.¹⁴

SUMMARY

The narratives and the drawings of children in the studies illustrate some developmental progressions. Simple expressions about single objects became more complex when comparisons were made, with comments about similarities, and later about differences. Finally, when sequencing skills had developed, relationships that are temporal, spatial, and causal were expressed; relevant details and multiple attributes were reported; sentence structures were more

¹⁴Beyond the report and illustrations of what the children in the studies drew, no analysis was attempted. In Lowenfeld and Brittain (1987), several approaches to analyzing children's art are described -- each interpreting what the children's productions might mean. The authors state the following about 'Art as a Means of Understanding Growth' (p. 59):

The picture that a youngster draws or paints is much more than markings on paper. It is an expression of the total child at the time of painting. ...Each drawing reflects the feelings, the intellectual capacities, the physical development, the perceptual awareness, the creative involvement, the aesthetic consciousness, and even the social development of the individual child.

Still another point of view could be that a child's picture is like a poem:

A poem should not mean
But be

(MacLeish 1935)

complicated and connected, fewer grammatical errors were made, and vocabulary was more sophisticated.

From the complementary abilities in what the children said and signed, in how they drew, and in how well they did the sequencing tasks, it would seem that they communicated much about what was in their minds.

CHAPTER 8

FOLLOW-UP STUDY

A COMPARISON OF SEQUENCING TASK SCORES AND REPORTED PROGRESS LATER AT SCHOOL

If we are like you in the rest, we will resemble you in that.

William Shakespeare
(The Merchant of Venice)

A follow-up study of the children in both the Preliminary Study and the Main Study seemed especially important when it was learned that several of the very low-scoring children were later having difficulties at school. Perhaps these children were not exceptions; perhaps there was an association between the sequencing task scores and later progress at school among the other children, low and high scorers, as well. If there were significant correlations, the tests would have a potential diagnostic and predictive value. Problems identified early in a child's schooling could receive attention and remediation, with future, possibly compounded, problems averted. Also, by analysing the tasks, we might be better able to define the skills, and a kind of intelligence, that schools consider superior.

The results reported in this chapter do show a statistically significant relationship between the test scores and the later ratings of the children in both studies separately and together, and with the children differentiated by handedness, sex, vision, and hearing status when all the items coded and rated are included. High scores combined with high ratings characterize the many hearing children and the children without visual impairments, also the few who are hearing, male, ambidextrous, and may have speech impediments. Low scores with low ratings are prevalent among the deaf children, the left-handed hearing girls, and the children with visual impairments.

SCHOOL REPORTS

As the time elapsed since testing was three years for the children in the Preliminary Study and two years for the children in the Main Study, a longitudinal comparison was feasible. A report form (in Appendix F) was sent to the present schools of all 80 children.¹ Information requested was about the children's classroom groups, speech/signing skills, writing handedness, physical coordination, vision, and general social skills.

Responses. The forms were completed for 77 of the 80 children (96%). They include all the hearing children and all but three deaf boys -- one in the Preliminary Study and two in the Main Study (10% of the deaf children in each study). Additional comments were made on 48% of the forms (for 34% of the hearing children and for 74% of the deaf children).

Report forms were returned from 30 schools -- three in England, the others in Scotland. The exact number of teachers who made the assessments can not be determined, as identification of the respondents had not been requested. From partial information, it is known that the minimum number of teachers who assessed the 77 children is 40. Such a diversity of schools and teachers, as well as the heterogeneity of the subjects, would increase the validity, and general applicability, of significant results. With significance levels high, differences in teachers' interpretations, in class compositions, and in measurement scales will have had little, or an equalizing, effect.

Report form ratings. Responses to twelve items on the report form allowed four of the categories to be coded: Classroom

¹About half of the children (41) had changed schools, 25 because the nursery school they attended when tested has no primary school adjunct. Of the others, 16% of the hearing children and 27% of the deaf children had changed schools. While the children had been in eight different schools when tested, they were in 31 different schools at the time the reports were sent.

Groups (*general, reading, and maths*); Speech/Signing Skills (*comprehension and intelligibility*); Physical Coordination (*handwriting, fine and gross motor skills*); and General Performance (*activity level, behaviour, sociability, and frequency of communications with peers*).

A five-point rating scale, from a low of 1 to a high of 5, was determined by the teachers' responses: No ratings were beyond 'low' or 'high' on the continuum, but intermediate ratings were given for 22 children (29%) and on all the items. *Reading, maths, and gross motor skills* had the most intermediate ratings (seven each). More than twice as many intermediate ratings were toward the highest than toward the lowest rating (37 versus 17). Together they comprise 6% of the total ratings, comparable to the 7% for the lowest ratings. With the intermediate ratings retained, rather than being randomly assigned to the major ratings, the teachers' responses were accepted as given, a greater scope for the individual ratings was provided, and the actual ratings could be compared to the actual test scores of each child.

Total numbers of subjects rated on each item range from 74 to 77 ($m=75.5$, 98%). Mean ratings are similar for the items within each of the categories:

Classroom Groups	3.3 - 3.5
Physical Coordination	3.5 - 3.7
Speech/Signing Skills	4.1 & 4.2
General Performance	4.3 - 4.8

Greatest differences are in the ratings of the items in the General Performance category: They have the highest mean, and mode, ratings (e.g. with *behaviour* rated as 'appropriate' for 91% -- all but seven -- of the children), and they have the fewest, lowest, only negative, and only nonsignificant correlations with each other, with the items in the other three categories, and with the total per cent ratings. Of the four General Performance items, *sociability* has the most and the highest significant correlations -- with *peer communications, speech/signing intelligibility, and total*

rating ($p < .001$); with *speech comprehension* ($p < .01$); with the *general* and *reading* classroom groups and *gross motor skills* ($p < .05$).²

Sociability also is the only item in the General Performance category that did not present coding problems. For one item in this category (*behaviour*), a continuum was not indicated on the form, and both *activity level* and frequency of *communications with peers* have potential ambiguities.³ Because of the possible differences in interpretations and the low correlations, the General Performance category was excluded from the per cent ratings calculated for comparison with the children's test scores. Therefore, unless otherwise specified, 'ratings' refer to the per cent total of the eight items in the other three categories.

While correlations are lowest for the General Performance items, they are highest for the items within the Classroom Groups category. They and the items in Speech/Signing Skills and Physical Coordination all have significant intercorrelations (shown in the following matrix, Table 8.1A), as well as the highest correlations with the total per cent ratings of all four categories (Table 8.1B).

²Correlations reported throughout are Spearman *rho* coefficients (r_s and probability percentages (p). Chi-square probabilities are indicated for the above- and below-mean distributions.

³A 'high' activity level could be considered either positively, as high energy and productivity, or negatively, as hyperactivity; a 'low' activity level might imply a positive quality, such as calmness or concentration, or a negative quality, such as passivity or lethargy. Frequency of *communications with peers* could be seen to reflect upon the teacher's classroom management (for example, ten of the 22 children for whom *communications with peers* were rated as 'occasional' were the ten children rated by one teacher).

Table 8.1: A. INTERCORRELATIONS OF REPORT FORM ITEMS

	Classroom		Speech/Signing Skills		Physical Coordination		
	<u>Reading</u>	<u>Maths</u>	<u>Intell'y</u>	<u>Comp'n</u>	<u>Fine motor</u>	<u>Writing</u>	<u>Gross motor</u>
<u>Classroom</u>							
General (m=0.62)	0.83***	0.86***	0.65***	0.68***	0.55***	0.49***	0.25*
Reading (m=0.57)		0.73***	0.59***	0.65***	0.51***	0.47***	0.24*
Maths (m=0.55)			0.57***	0.59***	0.50***	0.39***	0.20*
<u>Speech/Signing Skills</u>							
Intelligibility (m=0.53)				0.75***	0.45***	0.41***	0.28**
Comprehension (m=0.52)					0.34**	0.35**	0.28**
<u>Physical Coordination</u>							
Fine motor skills (m=0.52)						0.62***	0.66***
Handwriting (m=0.43)							0.27**
Gross motor (m=0.31)							

B. CORRELATIONS OF CATEGORIES
WITH TOTAL PER CENT RATINGS
OF THE FOUR CATEGORIES

Classroom Groups	0.89***
Physical Coordination	0.80***
Speech/Signing Skills	0.79***
-----	-----
General Performance	0.40***

* $r_s, p < .05$
 ** $r_s, p < .01$
 *** $r_s, p < .001$

(m = mean coefficient)

Of these items, *gross motor skills* has the least significant correlations, particularly with the three classroom groups; its only highly significant correlation is with *fine motor skills* ($p < .001$). In contrast, the five items in the Classroom Groups and the Speech/Signing Skills categories all have highly significant correlations with each other ($p < .001$). Were the ratings of a single category to be compared to the test scores, Classroom Groups would be the most representative; a single item would be the *general* classroom group.

SCHOOL REPORTS IN RELATION TO SEQUENCING TASK SCORES⁴

The children's ratings correspond to their scores: Most children who had high scores on the sequencing tasks received high ratings by their teachers, whilst most of those who had low test scores received low ratings. The relationship between the children's scores and their later school ratings is highly significant, especially for the children in the Preliminary Study.

The children's scores correlate significantly with their ratings in all four categories on the report form, and with the ratings on eight of the 12 items within the categories (Table 8.2). Correlations between scores and total ratings of the items in the three categories reported, and with the General Performance items included, are highly significant ($r_s=0.54$, $p<.001$). Note that Classroom Groups is not only the best single indicator of school progress; it is also the category most related to the test scores.

Table 8.2: CORRELATIONS OF SEQUENCING TASK SCORES
WITH SCHOOL RATINGS

Classroom Groups		0.52***
<i>Maths</i>	0.50***	
<i>Reading</i>	0.49***	
<i>General</i>	0.44***	
Speech/Signing Skills		0.46***
<i>Intelligibility</i>	0.46***	
<i>Comprehension</i>	0.41***	
Physical Coordination		0.32**
<i>Fine motor skills</i>	0.37***	
<i>Handwriting</i>	0.28**	
<i>Gross motor skills</i>	NS	

Total of school ratings reported		0.54***
General Performance		0.23*
<i>Sociability</i>	0.24*	
<i>Behaviour</i>	NS	
<i>Communications</i>	NS	
<i>Activity level</i>	NS	

Total ratings		0.54***

NS: nonsignificant

* r_s $p<.05$

** r_s $p<.01$

*** r_s $p<.001$

⁴For all 77 children to be considered together, the scores of the children in the Preliminary Study were also calculated according to age. The scores reported are their age-adjusted scores on the three abbreviated Main Study tasks.

The significance of these correlations is reflected in the distributions of the children with above-mean and below-mean ratings and scores (chi-square $p<.0001$). Numbers of children in each group in each study are shown in Table 8.3.⁵ Ratings and scores are in agreement for 75% of the 77 children: 31 children have both ratings and scores above the means and 27 children have both below the means; of the one-third in disagreement, ten children have high ratings but low scores, and nine have low ratings but high scores.

Table 8.3: RATING AND SCORE DISTRIBUTIONS REGARDING STUDIES

	Rating +m Score +m	Rating -m Score -m	Rating +m Score -m	Rating -m Score +m
Main Study children (n=58)*	23 (40%)	18 (31%)	10 (17%)	7 (12%)
Preliminary Study children (n=19)**	8 (42%)	9 (47%)	0 (0%)	2 (11%)
Total (n=77)***	31 (40%)	27 (35%)	10 (13%)	9 (12%)

+m = above mean

-m = below mean

* Chi-square $p<.005$

** Chi-square and Fisher's Exact Test $p<.001$ ⁶

*** Chi-square $p<.0001$

Both studies separately as well as together confirm a highly significant relationship between the school ratings and the sequencing task scores ($r_s=0.62$, $p<.005$, for the Preliminary Study; $r_s=0.54$, $p<.001$, for the Main Study). To note about the Preliminary Study is that with fewer children tested, fewer items in the test, and a greater time between testing and rating (three years versus two years), its correlations are actually more significant than the correlations of the Main Study: The scores and ratings of all but two children in the Preliminary Study are in agreement (a disparity of 11% versus 29% for the Main Study); the ρ value (0.62) and the above/below-mean rating-score correlation probability ($<.001$)

⁵As the means for both studies are similar, the numbers in each above- and below-mean group are the same whether the means used are for the total population or for each separate study.

⁶With few children in the Preliminary Study, the Fisher's Exact Test is the more appropriate test.

of the Preliminary Study are the higher.⁷ There is, therefore, an exceptional stability and validity of even the abbreviated sequencing tasks in predicting later reported progress in school.

Ratings in regard to hearing status.

The deaf children have significantly lower ratings and lower scores than the hearing children. On all but two items their ratings are lower, most significantly on *speech/signing intelligibility* and *comprehension*. Only on the frequency of their *communications with peers* do they receive significantly higher ratings than the hearing children. Of the Classroom Groups, it is the *reading* group on which the ratings of the deaf and hearing children are the most similar.

The difference between the hearing and the deaf children is highly significant on both ratings and scores ($r_s=0.32$, $p<.005$, for the ratings; $r_s=0.43$, $p<.001$, for the scores): The majority of the hearing children have high ratings and high scores (54%), but most -- and comparatively more -- of the deaf children have low ratings and low scores (63%). In Table 8.4 the low skew for the deaf children is shown in the above- and below-mean distributions of both groups.

Table 8.4: RATING AND SCORE DISTRIBUTIONS REGARDING HEARING STATUS

	Ratings*		Scores**		Ratings and Scores**				
	+m	-m	+m	-m	R+m S+m	R-m S-m	:	R+m S-m	R-m S+m
Deaf children (n=27)	8 (30%)	19 (70%)	6 (22%)	21 (78%)	4 (15%)	17 (63%)	:	4 (15%)	2 (7%)
Hearing children (n=50)	33 (66%)	17 (34%)	34 (68%)	16 (32%)	27 (54%)	10 (20%)	:	6 (12%)	7 (14%)

R = ratings

S = scores

* Chi-square $p<.005$

** Chi-square $p<.0005$

The correlation of ratings with scores is significant for the deaf children as well as for the hearing children when all

⁷When the median ratings and scores are used to differentiate the groupings, the distributions of, and the significance level for, the Preliminary Study children are identical to those derived from their mean ratings and scores; for the Main Study children, the medians alter the distributions so that a significant level of correlation is not attained for them ($p=.112$), and is decreased for all the children ($p<.005$ with the medians versus $p<.0001$ with the means).

twelve of the report form items are included ($r_s=0.33$, $p<.05$, for the deaf children; $r_s=0.50$, $p<.001$, for the hearing children), although not when the General Performance items are excluded ($r_s=0.28$, $p=.08$, versus $r_s=0.52$, $p<.001$, for the hearing children). A greater incongruity in the deaf children's ratings and scores could have been expected: The instructions to the teachers were for the ratings to be "relative to the other children in the classroom"; the scores of the children, however, were collectively compared, i.e. not with a separate scale for the lower scores of the deaf children, and yet the deaf children's ratings, as well as their scores, are low. The accuracy of the deaf children's ratings in relation to their test scores suggests their teachers nevertheless applied a realistic standard.⁸ The ratings which do not concur with the children's scores also suggest the absence of a bias: The proportions are similar for the deaf and the hearing children whose ratings and scores are discrepant (22% and 26%, respectively); the slant toward higher ratings with lower scores for the deaf children, but not the hearing children, is insignificant. (Had one deaf child instead had a low rating and a high score, the high-low difference among the deaf children also would be nil.)

Significant hearing-deaf differences are, as would be expected, in the ratings of the children's Speech/Signing Skills: Hearing status correlates with *intelligibility* ($r_s=0.51$, $p<.001$) and with *comprehension* ($r_s=0.32$, $p<.005$); in these communication skills, respectively 62% and 52% of the low ratings are for deaf children, 81% and 76% of the high ratings for hearing children. Other significant correlations

⁸A difficult objective of teachers of deaf children is to be objective -- to have realistic expectations and to accurately assess the children's abilities. With few deaf children in segregated classrooms, teachers' evaluations could be prejudicially low or high (i.e. low based on a spill-over of the children's language deficiencies (a 'horn' versus 'halo' effect), high because of magnification of small improvements and an everyday lack of comparison with hearing children norms. For example, of these 27 deaf children, 21 (78%) are in schools, not just classrooms, for the deaf.

are with *handwriting*, the *maths* group and the *general* classroom group ($r_s=0.30$ or 0.29 , $p<.01$), and with frequency of *communications with peers* ($r_s=0.23$, $p<.05$) -- the last being the lowest and only significant correlation that favours the deaf children. The single item on which most of the deaf children but not most of the hearing children were given above-mean ratings is *gross motor skills* (59% of the deaf children versus 38% of the hearing children) -- significant only in its being the exception.

Although the deaf children's scores correlate significantly with only two of the report form ratings, in contrast to the hearing children's six significant correlations,⁹ the inter-item correlation coefficients are generally higher for the deaf than for the hearing children. These reach a level of significance for the deaf children but not for the hearing children on two General Performance items:

- *Peer communications* correlates with *speech/signing intelligibility* ($p<.005$) and with *speech/signing comprehension* and *gross motor skills* (both at $p<.02$).
- *Sociability* also correlates with *speech/signing intelligibility* ($p<.005$) and *gross motor skills* ($p<.05$) and with *behaviour* ($p<.02$).

Inter-item correlations that are significant only for the hearing children are of *gross motor skills* with each of the three classroom groups -- the *general* and *maths* groups ($p<.005$) and the *reading* group ($p<.02$).

The *reading* group is the item within Classroom Groups that is least affected by hearing status differences, and is the most highly correlated to the scores of the hearing and the deaf children.

⁹The deaf children's scores correlate significantly with their ratings on *fine* and *gross motor skills*; the hearing children's scores also correlate with *fine motor skills* plus with the five items within the Classroom Groups and Speech/Signing Skills categories. Neither group alone has significant correlations of scores with ratings on *handwriting* or any of the General Performance items.

Ratings in regard to sex.

Sex correlates significantly with speech intelligibility, fine motor skills, and general behaviour, the girls having the higher ratings.

On all but one of the report form items, the girls' ratings are higher than the boys' ratings. The exception, as in the hearing and deaf children comparison, is on frequency of *communications with peers*, although the higher ratings of the boys do not reach a level of significance. The three items on which the girls have significantly higher ratings than the boys are *speech/signing intelligibility*, *fine motor skills*, and *general behaviour* ($p < .05$). (These three areas for the girls' superiority perhaps also would be expected.) The differences can be described by the above- and below-mean ratings: On *intelligibility*, a greater proportion of girls than boys have high ratings (73% versus 53% of the boys); on *fine motor skills*, more of the girls have high ratings (57%) while more of the boys have low ratings (60%); on *general behaviour* only one of the girls (3%) but six of the boys (15%) were rated below the mean. Likewise, although the scores of the girls and the boys correlate significantly with their ratings, the significance is higher for the girls ($r_s = 0.58$, $p < .001$, versus $r_s = 0.46$, $p < .005$).

Sex differences specific to the left-handed/ambidextrous children are reported in the next section.

Ratings in regard to handedness.

The ratings of the left-handed/ambidextrous children are similar to the ratings of the right-handed children. They are slightly but significantly lower on only two of the report form items -- *gross motor skills* and, again, frequency of *communications with peers*. It is among the left-handed/ambidextrous children that there are important differences: The left-handed/ambidextrous hearing boys excelled, all four having high ratings and high test scores. In contrast, only one (17%) of the left-handed/ambidextrous girls (who are hearing), and none of the left-handed/ambidextrous deaf children (all boys), had a high rating and a high score.

School information was available for 13 left-handed/ambidextrous children -- six girls and seven

boys.¹⁰ All the girls are hearing; four of the boys are hearing and three are deaf. One girl and four boys are ambidextrous. Four of the ambidextrous children (80%) but only two of the eight left-handed children (25%) had above-mean ratings. All three deaf children had below-mean ratings and below-mean scores.

The correlations of school ratings and test scores are significant for both handedness groups (with the ρ value actually higher for the few left-handed/ambidextrous children -- $r_s=0.76$, $p<.002$, versus $r_s=0.47$, $p<.001$, for the right-handed children). As shown in Table 8.5, the above- and below-mean distributions of the 13 left-handed/ambidextrous children are compatible with the distributions of the whole group of 77 children. The ratings and scores agree for 10 of the left-handed/ambidextrous children (five with both ratings and scores above the mean and five with both below the mean). This 77% agreement is in accord with the 75% agreement for all 77 children, for whom the rating-score distributions are well beyond chance (chi-square $p<.0001$).

Table 8.5: RATING AND SCORE DISTRIBUTIONS REGARDING HANDEDNESS

	Rating +m Score +m	Rating -m Score -m	Rating +m Score -m	Rating -m Score +m
Left-handed/ ambidextrous children (n=13)	5 (38%)	5 (38%)	1 (8%)	2 (15%)
Right-handed children (n=64)	26 (41%)	22 (34%)	9 (14%)	7 (11%)
Total (n=77)	31 (40%)	27 (35%)	10 (13%)	9 (12%)

Among the left-handed/ambidextrous children there is a sex bias: Four of the seven boys (57%) but only one of the six girls (17%) have above-mean ratings and above-mean scores. (As all four of the left-handed/ambidextrous boys who are hearing have high ratings and high scores, that 100% further contrasts to the 17% of the six hearing left-handed/ambidextrous girls.) Of the right-handed

¹⁰Information was not available for Samuel, the left-handed boy whose test score ranked highest among the deaf children.

children, 15 of the girls (48%) and 11 of the boys (33%) have above-mean ratings and scores, i.e. 15% more girls than boys as well as 31% more right-handed than ambidextrous/left-handed girls. Therefore, the left-handed/ambidextrous girls deviate from all the other children.¹¹

Mean groupings also clarify the two ratings which have significant correlations with handedness ($p < .05$) -- both slightly favouring the right-handed children. The *gross motor* ratings of the right-handed children are equally distributed below and above the mean (with 32 children in each group), but among the left-handed/ambidextrous children, they are predominantly below the mean (with 10 children below and only three above). The skew is reversed in the *communications with peers* ratings: Similar numbers of the left-handed/ambidextrous children were rated below and above the mean (a 7-6, 54%-46%, split), whilst most of the right-handed children (72%) were rated above the mean.

By mean groupings the similarities between the left-handed/ambidextrous children and the right-handed children on all the other ratings are particularly evident. For example, there is no difference between the handedness groups in the proportions of children with above- and below-mean ratings on six items -- the *reading* and *maths* groups, *speech intelligibility*, *handwriting*, *activity level*, and *general behaviour* (chi-square $p = 1.000$ for each).

¹¹Particularly discrepant are the below-mean ratings for Zoe and Tessa, two of the three left-handed girls who had scored above the mean on the sequencing tasks. For both girls, the three Classroom groups were reported as 'middle', yet their test scores were exceptionally high. Zoe's age-adjusted score on the three tasks included in the Main Study was the second highest of the 20 children in the Preliminary Study (the highest on all the tasks in the Preliminary Study), and Tessa's rating was sixth among the 60 children in the Main Study. More information would be needed to explain why these two girls are the only left-handed/ambidextrous children, among a total of only nine children, whose test scores were high but whose subsequent ratings were low.

The superiority of some of the left-handed/ambidextrous children is seen in their reported Classroom groups: The four left-handed/ambidextrous children whose Classroom ratings as well as scores are above the means were all reported to be in the 'high' *general*, *reading*, and *maths* groups.¹² Their 100% contrasts to 48% of the right-handed children whose Classroom ratings are maximum. Of the children whose reported Classroom groups are the minimum (all three 'low') and whose scores are below the mean, proportions are similar for the left-handed/ambidextrous children (40%) and for the right-handed children (33%). Thus, it is the left-handed/ambidextrous children with high Classroom Group ratings who are outstanding, in terms of both difference and eminence.

OTHER SCHOOL REPORT ITEMS

Four items on the school report form which had no gradations of response possible would not have been appropriate to code and include in the ratings. The teachers' responses to these items are recorded in this section.

Speech/signing impediments.

The only hearing children reported to have speech impediments are boys who have exceptionally high ratings and scores, and mixed handedness ratios.

Response options on the form were 'none', 'lisp', 'stutter', and 'other'. Of the 27 deaf children, *speech/signing impediments* were indicated as 'none' for 12 (44%). 'Lisp' was indicated for one and 'other' for four. For ten deaf children, this item was left blank, although for seven of them, as for those with 'other' circled, speech/signing skills and defects were commented on.

¹²The four children are one girl and three boys, two left-handed and two ambidextrous. One other ambidextrous child, Joel, was not rated on Classroom groups, or *handwriting*, with "not relevant" noted; however, his ratings on all the other items are the maximum possible.

'None' was indicated for 48 of the 50 hearing children (96%), one with a question mark added. 'Other' was reported for two hearing children, with a pronunciation substitution ('w' for 'r') specified for one. These two children are Joel and Ernest -- the two boys for whom each item rated was the maximum possible. By scores, of the 32 boys in the Main Study, they rank first and third. The boy who ranks second (Martin) is the one hearing child for whom 'none' was circled but questioned. Although only Joel is ambidextrous, the Task Handedness Ratios (THRs) of all three boys indicate mixed handedness: The ratios of .249 for Joel and .371 for Ernest are each less than .1 from the mean (.292).¹³ Martin's THR of -.147 is the only negative THR of the right-handed boys. Implications of the associations between the mixed handedness, the exceptionally high scores, and the reported speech defects of these boys are discussed in the Conclusions chapter.

Writing hand.

The writing hand reported is in total agreement with the right- and left-handed categorizations of the children in the studies.

The hand used for writing was not indicated on the forms of three children, categorized as right-handers. (Of the three children whose forms were not returned, one is left-handed.) Sixty-five children (88%) were reported to write with their right hands, nine (12%) with their left hands. Among those reported to write with their right hands are three ambidextrous children who when tested had written their names with their right hands, plus one ambidextrous child who had written her name with her left hand. The only ambidextrous child reported to write left-handed is Joel, who had alternated between his left and right hands when he wrote his name (and when he drew a picture). Therefore, except for the two ambidextrous children, all remained consistent in their

¹³The handedness scale, from -1 to +1, has a possible range of 2.0. The actual range of the THR (i.e. the mean of the three task ratios) for the 60 Main Study children is 1.5.

handedness.

Vision.

Vision correlates significantly with scores and ratings. The ratings of the children with visual impairments are lower than the ratings of the children without visual impairments on every item except *behaviour*. Significant differences are on *speech/signing intelligibility* and *comprehension* and on *fine* and *gross motor skills*.

Because the particular motoric component of these skills related to vision is relevant to manual coordinations, the children with visual impairments, and predominantly inferior ratings and scores, are described in detail in this final section.

The first item in the Vision section asked if eyeglasses are worn. Of all 77 children accounted for in the replies, six (8%) were reported to wear glasses.¹⁴ (Only one child had worn glasses when tested -- Simone, at age 3:9.) Comments were added on the reports of two children wearing glasses and two children not wearing glasses.

Of the six children wearing glasses, four are boys, three are deaf, two are left-handed and one is ambidextrous. There is, then, a higher proportion of children with glasses who are categorically considered more 'at risk'. (Being a boy, deaf, and left-handed, William qualifies in all three categories.)

¹⁴Three children in each study were reported to wear glasses, i.e. 16% of the children in the Preliminary Study and 5% of the children in the Main Study. The three-times greater percentage for the children in the Preliminary Study can be explained by the extra year between their testing and reporting times (three versus two years) and by their ages: They are four months older by mean age (seven months older by median age) than the children in the Main Study.

The other question in the Vision section is about the presence or absence of a *squint*.¹⁵

There was no response to this item on the forms of 13 children, only one with a comment. This 16% contrasts to 4% for the highest response omissions with no comment on the other items. The four-fold difference could reflect uncertainty or reluctance more than oversight.

Only one child was reported to have a squint. He is William, the deaf child now wearing glasses about whom his teacher commented, "[His] learning difficulties appear to relate to undetected poor vision and lack of communication skills at an early stage." His squint had not been detected when he was tested two years prior to the report. However, on re-examination of the videotape, slowed to 40-millisecond frames, a squint is evident at the time of his transferring his focus from a close to a further distance. (Several times during the testing, he closed or covered one eye. He used his left eye exclusively when viewing through the aperture of the camera and the kaleidoscope.)

Three of the 13 children for whom there was no response to this question had been suspected of having a squint when they were tested.

- Tarini, the child whose squint was most pronounced at the time of testing, was reported not to wear glasses but to have "no effective vision [6/60] in her right eye".

¹⁵This question was asked because of the exceptional handedness patterns and especially high and low scores of children observed to have a squint. It was recognized, however, that except in extreme cases, strabismus can be difficult to detect. A squint may be transient, apparent only at times of fatigue and/or stress or when focussing on an object at a specific angle or distance. There is also the human element -- the tendency both to see what is looked for and not to see what is not looked for, or not wanted to be seen. Reports of teachers' observations and still-frame videotape analyses cannot confirm but can suggest the presence of a squint. The immediate cue of a squint would be of importance if ocular imbalance can be associated with manual and hemispheric asymmetries, specifically of the dominance of one side because of a deficiency of the other side. Were the suspicion of a squint reported, referral and remediation could follow.

- Calum, also reported not to wear glasses, had had a conspicuous right-eye squint when he was re-tested. The only possible indication of a squint from the videotape of when he was first tested is when he was focussing on objects directly in front of him. (During the Handedness-Sidedness Inventory, he had preferred to look through the kaleidoscope with his right eye, stating "It's darker" with his left eye, and to hop on his right foot, saying it was "better, because my left one, I haven't much balance". It was noted that his only uncorrected error when doing the three Main Study tasks was the misplacement of a clown cutout -- at his midline.) Chronologically, there was the possibility of a slight, intermittent squint at the age of 5:0; certainty of a squint at 5:9; no report of either the presence or absence of a squint at age 7:7.
- Scott was reported (at seven years of age) to wear glasses to correct his distant vision. He is one of the Preliminary Study children who was re-tested with the order of the tasks randomised. At both times (at the age of 4:0 and 4:6) a squint was apparent, most decisively when he looked directly at the camera or up at the ceiling. Still-frame sequences indicate a right-eye weakness.

In addition, five children reported not to have a squint had been suspected of having a squint when they were tested. Table 8.6 summarises information on the nine children who had a detectable squint. The other four children reported to wear glasses are included to complete the data on children with visual impairments.

Table 8.6: CHILDREN WITH VISUAL IMPAIRMENTS

		<u>Squint</u>	<u>Glasses</u>	<u>Rating</u>	<u>Score</u>
WILLIAM	(l)	yes	yes	- <	-
Scott	(a)	yes	yes	+ >	+ >
Calum	(a)	yes	no	+ >	+
SEAN	(r)	yes	no	+	+
HAMISH	(r)	yes	no	+	-
JASPER	(r)	yes	no	-	+
TARINI	(r)	yes	no	-	- <
Shelagh	(r)	yes	no	- <	- <
LUCY	(r)	yes	no	- <	- <
Gordon	(r)	no	yes	-	-
JIMMY	(r)	no	yes	-	- <
SIMONE	(r)	no	yes	-	-
Judy	(l)	no	yes	-	-

deaf children; MAIN STUDY CHILDREN

(l: left-handed; a: ambidextrous; r: right-handed)

+ = above-mean rating/score

> = maximum Classroom rating/highest score

- = below-mean rating/score

< = minimum Classroom rating/lowest scores

Greater extremes are among the children suspected of having a squint: Only they had both ratings and scores above as well as

below the means, and only they had maximum and minimum Classroom ratings. The two boys who had maximum ratings are the two who are ambidextrous; one (Scott) is the child in the Preliminary Study whose age-adjusted score was the highest.¹⁶

Also in the visually impaired group is the child in the Preliminary Study whose unadjusted score was the lowest, in addition to the three lowest-scoring children in the Main Study. (The three lowest-scoring Main Study children represent 5% of all the children in the Main Study but 38% of the Main Study children who are visually impaired.) Of the six children in the Main Study hearing-deaf dyad group whose handedness patterns had signalled a manual-visual eccentricity, the two who received above-mean ratings (Sean and Hamish) have the most leftward THRs of these right-handed children (.138 and .090, respectively).¹⁷

The ratings and scores of all the children with visual impairments are significantly lower than the ratings and scores of all the children without visual impairments ($r_s=0.26$, $p<.02$, for the ratings; $r_s=0.23$, $p<.05$, for the scores). Separately, as well as collectively, the rating-score correlations are significant ($r_s=0.64$, $p<.01$, for the visually impaired children; $r_s=0.47$, $p<.001$, for the nonvisually impaired children -- with the ρ value higher for the 13 visually impaired children, as it is for the 13 left-handed/ambidextrous children). Above- and below-mean distributions are shown in Table 8.7.

¹⁶Scott's maximum rating and highest score contrast to William's lowest rating and low score (and sole identification of learning difficulties). Although they are alike by being the two children who wear glasses and have had a squint, other differences are that Scott is hearing and ambidextrous, William deaf and left-handed. (Note that of the 13 children who have visual impairments, four are left-handed/ambidextrous and four are deaf -- a 31% incidence contrasting to the incidence of 17% for left-handedness/ambidexterity and of 15% for deafness in the whole follow-up population.)

¹⁷Lucy's mother reported that she was being consulted about having Lucy repeat her first year at school, and commented that when Lucy wrote her name (that is six letters long), she would reverse the middle two letters.

Table 8.7: RATING AND SCORE DISTRIBUTIONS REGARDING VISION

	Ratings		Scores		Ratings and Scores		
	+m	-m	+m	-m	++	--	+/-/+
Children with visual impairments (n=13)	4 (31%)	9 (69%)	4 (31%)	9 (69%)	3 (23%)	8 (62%)	2 (15%)
Children without visual impairments (n=64)	37 (58%)	27 (42%)	36 (56%)	28 (44%)	28 (44%)	19 (30%)	17 (27%)

The lower ratings of the visually impaired children on all the items except *behaviour* reach a level of significance in the Speech/Signing Skills and Physical Coordination categories ($r_s=0.34$, $p<.005$, for *speech/signing intelligibility*; $r_s=0.27$, $p<.01$, for *speech/signing comprehension*; $r_s=0.27$ and 0.25 , $p<.02$, respectively, for *gross* and *fine motor skills*). Table 8.8 shows the above- and below-mean groupings on the significantly related items.

Table 8.8: SKILLS RELATED TO VISION

	Speech/Signing Intelligibility**		Speech/Signing Comprehension**		Gross Motor Skills*		Fine Motor Skills	
	+m	-m	+m	-m	+m	-m	+m	-m
Visually impaired children (n=13)	3 (23%)	10 (77%)	4 (31%)	9 (69%)	2 (15%)	11 (85%)	3 (23%)	10 (77%)
Nonvisually impaired children (n=64)	45 (70%)	19 (30%)	42 (66%)	22 (34%)	33 (52%)	31 (48%)	34 (53%)	30 (47%)

* Chi-square $p<.05$

** Chi-square $p<.01$

The lowest ratings for the visually impaired children were on *gross motor skills* (85% -- a 70% difference between their above- and below-mean ratings contrasting to the 4% difference for the nonvisually impaired children). On *speech intelligibility* and *comprehension*, their below-mean ratings correspond closely to the others' above-mean ratings.

The overall lower ratings and scores of the visually impaired children, the greater discrepancies between them, their higher incidence of left-handedness/ambidexterity and of deafness, and the specific skills on which they differ the most from the nonvisually impaired children would warrant further attention and investigation.

SUMMARY

The sequencing task scores reliably predicted the children's reported school progress: The scores of the children in the two studies correlate significantly with their ratings, most significantly on Classroom Groups. The deaf children differ from the hearing children by having both lower scores and lower ratings, especially on their Speech/Signing Skills. Only on the frequency of *communications with peers* do they -- and the boys -- have higher ratings than their counterparts. In general, the girls excel, most in their ratings on *speech/signing intelligibility, fine motor skills, and behaviour*. In particular, however, the left-handed/ambidextrous girls have inferior ratings, whereas the left-handed/ambidextrous hearing boys have superior ratings and scores. Mixed handedness also characterizes the boys who have exceptionally high scores and ratings and are reported to have speech impediments or visual impairments. While only one other visually impaired child has both a high rating and a high score, four visually impaired, right-handed, children have low ratings and lowest scores. A common motoric component links vision and handedness with the skills on which the visually impaired children have lower ratings (Speech/Signing Skills and Physical Coordination). Their resemblances are in their differences.

Implications of these results are discussed in Conclusions, the next and final chapter.

CHAPTER 9

CONCLUSIONS

'One can't, perhaps,' said Humpty Dumpty, 'but two can.'

Lewis Carroll (1984, p. 98)

This research has investigated the relationships between parts: how each hand functions in relation to the other and how objects are perceived to relate to each other. The conclusions are based on the responses of 80 young deaf and hearing children. The data are counts of their actions while manipulating the test materials, their spoken and signed comments, and the arrays they constructed with the objects. Interrelationships between the children and others were not investigated, although the influence and impact of deaf people's experiences are discussed (in Appendix D).

RESEARCH RESULTS: FACTORS SIGNIFICANTLY RELATED TO SEQUENCING ABILITIES

1. *Hearing status.* Significant differences between groups of deaf and hearing children were related to the age of the children and the type of the task. On three sequencing tasks, the scores of the hearing children were significantly higher than the scores of the deaf children -- both among the 20 four- and five-year-old children in the Preliminary Study (PS) and among the 60 three- to seven-and-a-half-year-old children in the Main Study (MS). These three tasks require an understanding of relationships and an ability to represent relationships in a conventional left-to-right sequence: for a first-to-last temporal order of events in sets of picture cards (the most difficult task), for smallest-to-largest size progressions, and for three-part shape pattern continuations (of these three tasks, the one on which the deaf children most approximated the hearing children in ability).

In contrast, the other three tasks presented to the Preliminary Study children were accomplished equally well by the deaf as by the hearing children. These tasks differ by requiring no linear placements of the materials and no judgments about order, but instead require memory skills: in recollecting the order of pictures in a storybook, in repeating three-part clapping patterns, and in imitating series of movements. Other nonsignificant differences between the children were a) when eight children in the Preliminary Study repeated the tasks one year later and b) when the age range of the deaf children in the Main Study was extended upwards (to seven-and-a-half years, so their mean age was nine months older than the mean age of the hearing children) and the scores were not adjusted for this age difference.

2. *Handedness patterns.* Higher scores were significantly correlated with greater left hand use (PS) and significantly related to categorical left-handedness (MS). Significantly lowest scores were those of the children who had the most mixed handedness patterns.

3. *Birth order.* The total scores of the PS children and the age-adjusted scores of the MS children were significantly higher for those who are first-born (or only children) in comparison with the scores of those who have elder siblings.¹

4. *Age and name-writing ability.* Older children and both older and younger children who could write their names had significantly higher scores.

5. *Later ratings of classroom performance.* For all the children (77 of the 80 children in both studies), there were significant positive correlations between the sequencing task scores and the ratings by their teachers two or three years after the testing: in total ratings and ratings in the

¹See Hartog (1974) for an excellent discussion of birth-order effects -- and the success-oriented characteristics, achievements, and problems of oldest siblings.

specific areas of classroom groups, speech/signing skills, physical coordination, and sociability.

OTHER FINDINGS

1. *Handedness patterns.* Associations with higher scores include the following:

- Greater lateralization, indicated by a) the re-test score improvements and more rightward handedness ratios of the right-handed children and more leftward ratios of the left-handed children; b) the higher scores on the tasks that did not constrain the children's hand movements within a narrow, middle area.
- Greater differentiation in the hand used for different functions: in placing versus in collecting materials, and particularly in collecting all items exclusively with the left hand.
- Greater continuity, expressed in collections that were cumulative and across the body midline.

2. *Errors.* Numbers and types of errors showed progressions in perceptual awareness: at first paying no attention to features that differentiate the objects (by placing them in the order of contact, from the top to the bottom of a pile, as one deals cards, and making no comparative inspections or visual references to stimulus sets), and later indicating perceptions of similarities, and then differences, between items. Errors decreased as double properties and multiple relationships were perceived, i.e. that an attribute or state of an object determined its relative position (for example, that a shape is not only red but, within a pattern, it is also first).

3. *Additional handicaps.* Most of the children who had a detectable squint and deaf children whose aetiology is in a 'high risk' category were among the lower, and very lowest, scorers.

DISCUSSION OF THE MAIN FINDINGS

The significant relationships found between the children's sequencing task scores, hearing status, and handedness patterns raise questions about the mental abilities required for these tests to be completed successfully. Possible answers, suggested by the results of the thesis laterality studies, are discussed with reference to results of, and questions posed by, studies reviewed in the Introduction chapter. Significant results based not on one study alone but rather on the accumulation of consistent research findings can inform us more accurately about the cognitive functioning of deaf and hearing children.

1. *Sequencing task scores and hearing status.* A general disability of the deaf children was to express temporal and spatial relationships in a linear left-to-right order. An inference is that without sufficient hearing, children will not only have less linguistic competence but also delayed acquisition of sequential processing skills. Unimpaired auditory reception could well support the development of a time-ordered disposition. Hearing children are aided through experiencing spoken communications in which the order of sounds within words and of words within sentences is essential to understanding the meaning intended. Their habitual encoding and decoding of messages would involve an awareness and expectation of acoustic order which would reinforce a temporal sequential organization of information. For deaf children -- those who have fluctuating hearing losses as well as those who have severe to profound hearing losses within the speech range, a greater synthesis of partial and distorted information will be required *in addition to* an ability to analyze and perceive the relationships between the components of a spoken message. Furthermore, a reliance upon vision and use of sign languages might both strengthen simultaneous processing and reduce, if not conflict with, perception of the linear quality of spoken languages. A consequence could be -- and evidence in the thesis studies is -- that deaf children will demonstrate an inferior ability in linear sequential

arrangements of test materials. This result supports the following findings of other researchers.

- Developmental delays and reading difficulties occur among children who have mild intermittent hearing losses (Webster 1986).
- Deaf children have specific memory span difficulties; scores on these tests correlate more significantly than scores on other memory tests with reading achievement scores (Blair 1957).
- Deaf children exhibit an inferiority in recalling visual material presented in a successive sequential order but not with simultaneous presentations (Withrow 1968).
- Spatial strategies in the responses of deaf children contrast to temporal strategies employed by hearing children (O'Connor and Hermelin 1973, 1976; Hermelin and O'Connor 1975a and 1975b).
- Deaf children appear to depend on a visual system for processing visual stimuli, whereas hearing children appear to transform visual information into a verbal code and to use a dual system for developing symbolic relationships (Kelly and Tomlinson-Keasey e.g. 1976).
- Hearing-impaired children show difficulties on tasks that require an integration of sequential and simultaneous processing; scores on the Photo Series subtest of the Kaufman Assessment Battery for Children have high correlations with arithmetic computation and reading comprehension scores (Kaufman and Kaufman 1983).
- Deaf students' literacy and academic achievement are reliably predicted by their scores on the Picture Arrangement subtest of the WAIS and on the Test of Syntactic Abilities (Moores and Sweet 1990).

All together, and without exception, these studies (and others) indicate that an ability to order information sequentially is an important measure of achievement and that deaf children in comparison with hearing children demonstrate a weakness in sequencing skills. Contributions of the thesis studies are to have shown that a) this difficulty exists among deaf children who are from three to seven-and-a-half years old (i.e. not only deaf children who are older -- from seven to 17 years old, as shown in other studies); b) the young deaf and hearing children have comparable memory skills; c) the deaf children have a specific disability on tasks requiring a linear orientation and judgment of a temporal-spatial

organization of information.

However, as these results are based on mean group performances, in this research consideration was also given to individuals (e.g. to the deaf children who excelled on all the thesis sequencing tasks) and to the effects of different aetiologies of deafness (e.g. those that are 'high risk' versus those that are genetic, and the large proportion that are 'unknown'). Also, because collectively the younger children were less successful, similarities between them and the deaf children needed to be explored. Individual children described and subgroups analyzed in the thesis provide additional information both to clarify the general results and to investigate exceptions.

2. *Sequencing task scores and patterns of hand use.* The significant correlation of lowest scores with mixed handedness patterns is not an isolated finding. Lower achievement has consistently been found in people who exhibit mixed preferences: 'mixed handedness' and 'crossed lateralization' (Porac and Coren 1981), 'ambiguous handedness' (Naidoo 1961), motoric 'intergrades' (Orton 1937).

...there is reason to believe that a high degree of specialization in either hemisphere makes for superiority and that the good left-hander is therefore not only not abnormal but is apt to be better equipped than is the indifferent right-hander. (Orton 1937, p. 50)

In the Main Study, the presence of some exceptionally high scorers among the children in the middle-right handedness group and others with more extreme handedness ratios can be explained by their systems of differentiation. Their hand functions are selective for specific actions (e.g. collecting materials exclusively with the left hand) and for a specific task (e.g. arranging objects in size progressions). Higher scorers will also maintain a continuity of direction in their movements, make comparatively more contralateral reaches, and use one hand dominantly at the body midline. The increasing degree of manual specialization, documented by Gesell and Ames

(1947) and seen also when right- and left-handed children in the Preliminary Study were re-tested one year later, is associated with other developmental progressions and specializations. Motoric correspondences include progressions in language acquisition (Ramsay 1980, Ramsay and Weber 1986), cerebral maturation (Lenneberg 1967), and hemispheric specialization (Thatcher et al. 1983). Gestures are seen to complement speech (McNeill 1985a, 1985b, 1992) and, with age, to become more specialized and precise and more coordinated with speech (Kendon 1986).

The thesis findings that only deaf children who use total communication and all the deaf children who have a 'high risk' aetiology are included within the middle handedness group and that oral deaf children have extreme left- and right-hand ratios are relevant to the reports of decreased hemispheric specialization among deaf -- particularly nongenetic deaf -- school children (e.g. Wolff and Thatcher 1990) and of asymmetric functioning among oral deaf college students (Phippard 1977). The handedness patterns of the young deaf children in the laterality studies are compatible with the hemispheric characteristics of older deaf populations and demonstrate a manual-mental link.

3. *Sequencing task scores and reported progress later at school.* Results of the thesis studies as well as other studies cited above show an interrelationship between sequencing scores, reading and writing skills, and academic achievement. The scores of the children in the laterality studies correlate significantly with name-writing ability and with teachers' ratings of the children's performance at school two or three years later. Ratings on the classroom groups alone and together with the other categories (speech/signing skills, physical coordination, and general performance) have correlation coefficients of greater than 0.50 ($p < .001$).

High scores and high ratings for the hearing children contrast significantly to low scores and low ratings for the deaf children. The only item on which the deaf children were rated

higher than the hearing children is on the frequency of communications with peers; greatest differences between the ratings are in the the speech/signing skills category, and the least difference is on the reading group ratings.

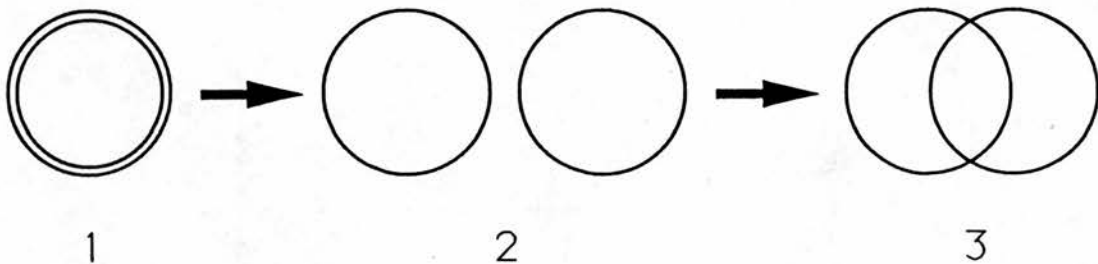
The following three results were unexpected.

- A sex bias was found among the left-handed/ambidextrous children: Scores and ratings were high for most of the boys while both were low for most of the girls. (Two left-handed girls had exceptionally high sequencing task scores but only moderate, below-mean ratings.)
- The only hearing children reported to have or possibly have a speech impediment are similar in several ways: All three are boys; their scores rank the highest of the boys in the Main Study; their hand movements while doing the tasks were characterized by ambidexterity; two received the highest possible ratings.
- Children who had visual impairments (either a detectable squint or an impairment corrected by glasses) had lower scores and lower ratings than the children without visual problems. Significantly lower ratings were on speech/signing intelligibility and comprehension and on fine and gross motor skills. Only the (hearing) ambidextrous boys had high or highest ratings and/or scores.

When these last results are considered with the other results of the laterality studies, a pattern emerges: Impairments in hearing and in vision are associated with less success on sequencing tasks and in classroom performance. The specific deficit in the speech/signing and motor skills of the visually impaired children, the exception of boys who exhibited ambidexterity, i.e. skill with both hands, along with the success of children who used both hands in systematic ways imply an importance of balance -- coordination of specialized sensory-motor functions -- for mental development.

INTERPRETATIONS: DEVELOPMENTAL STAGES

Patterns in the children's hand movements suggest progressions from bimanual use that is at first simultaneous and undifferentiated and at last systematic, differentiated, continuous, and coordinated. Corresponding patterns in the arrangements of the test materials show symmetry and similarity at first and later a logical sequential ordering. The hypothesized cognitive correspondence is that there is a progression from a general perception to an awareness of specifics and then an understanding of interrelationships. In hemispheric terms, this progression could be from more right hemispheric towards more left hemispheric processing, and finally to an integration of the two. A simple diagrammatic representation of these three (manual, material, and mental) evolutions could be like this:



A grammatical analogy would be the three types of sentences: simple, compound, and complex. The stages similarly relate to the personal, interpersonal, and social spheres. Each stage will be described in order, with examples from the testing and references to the literature.

Stage One: Unity and Symmetry

The younger children in the Laterality studies displayed classic Piagetian egocentrism: a 'me' concentration with a middle preference and a situation immediacy. They are very much at the centre of their universe, and the space at the middle of their bodies has special prescripts. At this first stage, that is where a first object is placed, and around

which the other objects are arranged, often according to a Law of Symmetry; it is where, when the two hands come together, objects are most frequently dropped. When a centre placement is incorrect, that object is the least likely to be changed but the most likely to be removed first. When a left-to-right placement orientation is adopted, the centre is where the object of greatest importance to the child is placed. This importance is shown verbally and non-verbally: It is the picture either most or exclusively talked about, the object which is most frequently touched or most visually fixed upon.

Examples of recurring centre-choice placements among the three-series pictures (see Appendix A) are the apple being eaten, the girl falling off the swing, the door being painted, the foreground boy holding the kite up, and the people boarding the bus. These can be categorized as the 'theme' cards, depicting the principal action of the events, and with the apple and door sets, it is only this card that shows a (part of a) person as well as an action. With the circus objects, it was often the conspicuously biggest clown that was placed in the centre, at the child's midline.

The midline also was important at this stage regarding the children's hand movements. It presented a somewhat inviolable space not traversed by contralateral reaches. A child would shift his body rather than cross his midline, or would transfer a pile of objects, held in a central position, so that arm extensions were predominantly ipsilateral (made in the rightward space with the right hand and in the leftward space with the left hand).²

²This characteristic was also observed when young children were indicating directions they would go to cross a street. (My data from this road safety project have not yet been analyzed to determine correlations between the children's gestures and their incorrect or correct responses, before and after instruction.) One child in particular was so extreme when baseline data were collected that she laboriously (and needlessly) transferred the string of a purse from one shoulder to the other each time before pointing ipsilaterally, as though not to transgress by trespassing a sacred midline territory.

Other prevalent Stage One behaviours were immediate, rather than considered, placements; apparent indifference to sidewise and upside-down placements; no corrections or insertions; and one-by-one, rather than cumulative, collections of the materials. The children would match shapes of the same colour and would comment about things that were the 'same' and that 'go together', or about unimportant details.³

Of relevance are the findings that three- and four-year-old children tend to focus and fixate on the centre of an irregular form, versus five- to seven-year-olds who visually scan the entire internal space and trace the outline of a figure -- and later they, but not the younger children, correctly recognize the perceived object (Zaporozhets 1961 and 1965).⁴ Wood (1988) also found that visual inspection patterns of a four-year-old were brief and partial, whereas an eight-year-old's were systematic and thorough. Kinsbourne and Hiscock (1983) report that lateral eye movements (LEMs) are minimal until the age of four, and Mackworth and Bruner (1970) that scanning space increases with age, i.e. with the average length of six-year-old children's eye tracks two-thirds that of adults. Also associated are visual anomalies such as squints, when eye muscles are imbalanced in strength and an eye turns inwards, and the binocular instability and impaired ability of dyslexics to identify, or 'de-mask', combinations of letters at the central foveal field (Grant 1985, Geiger and Lettvin 1987).

³Young (1978) describes similar behaviours of young children when doing a seriation task; Sugarman's (1987) observation was that, with a search task, younger children were 'just picking daisies', not yet testing hunches to verify their choices. Classically, children at this first cognitive stage fail in conservation tasks (Furth 1973): Their responses reflect judgments based upon the appearance of one dimension (e.g. with 'more' equated to a higher level of liquid) and a disregard of other measurement changes (e.g. of a wider container).

⁴Data analogous to the changes from visual central fixations to exploratory movements were found in children's tactile responses (Zaporozhets 1965): Between three and six years of age, single whole-hand movements changed in stages to systematic two-handed palm and fingertip examinations of objects -- again with the movement precisions correlated with effective perceptions.

Among deaf people, different eye movement patterns have been reported. When Wood et al. (1986) examined the eye movements of children while reading, they found that the deaf children, but not the hearing children, read word-by-word. Gibson and Segalowitz (1986, p. 220) comment more generally: "...the deaf appear to have abnormal eye movement patterns."

Difficulties, if not inabilities, in visually crossing the body midline are thought to be a reliable sign of disorders in bilateral integration (Ayres 1974). Manual midline crossing is absent at a stage in infants' reaching and grasping attempts (Bruner 1974) and increases in the spontaneous movements of four- to eight-year-old children (Cermak, Quintero, and Cohen 1980).⁵ Complementary progressive increases in interhemispheric transfer of information are implied in O'Leary's (1980) tactile/kinaesthetic study (mentioned in Chapter 1). Marie Banich (personal communication) has proposed that the deficit of young children's ability to integrate information across the body midline is related to an inability to direct attention throughout the entire perceptual field and/or to limited interhemispheric transmission because the central cortical commissures are not yet fully functional.

Stage Two: Duality and Asymmetry

The centring proclivity, accompanied with a salience of similar two-handed movements and the creation of rather symmetrical patterns, later yields to a detection of differences between segments, an awareness of duality, and lateralized dominance. It is specifically at this middle stage, of differentiation (and at the last stage, of

⁵About the 'first analogue of reaching' of six- to eight-week-old infants, Bruner (1974, p. 274) comments:

I should like to emphasize that the two hands are not acting to complement each other, but are in synchrony at the midline. One hand will not cross over the midline to help the other get an object to the mouth or even to get a grasp on it.

differentiation plus integration), when deaf children's abilities have seemed deficient.⁶

Dual patternings were expressed when children sorted objects by size a) with polar contrasts (e.g. by separating the three smaller and the three larger objects and by placing the smallest object on the largest) or b) with paired selections (e.g. by combining in play the two objects of most similar sizes and by the common order error of reversing sequential pairs). Comments would be about 'different' (often irrelevant) details. In handedness, differentiation emerges: There is a consistency in the hand that is dominantly active or supportive. For example, a child will hold the pile of objects in one hand throughout the placements or collections, rather than transferring the pile at the midline and alternating hands.

While the dual patterning contrasts to and evolves from the strong 'magnetism' of centring, it seems also to have a potential either to create or to resolve conflicts.

A first clue that there could be a conflict when the two hands are used simultaneously, and equally (i.e. without one subordinate, as when providing a holding 'frame' for the 'content' operation of the other hand [MacNeilage, Studdert-Kennedy, and Lindblom 1984]), came from the 'stuck' behaviour of the deaf boy who scored the highest of the children in the Preliminary Study. This occurred at the time he was holding two yellow triangles, one in each hand, in a parallel position. Only afterwards when he had only one in one hand (and had searched on the floor for what might have been a missing shape) was his dilemma resolved.

⁶Furth (1973) found deaf and hearing children equally able to identify 'same' pictures and equally unable to discriminate symmetrical from asymmetrical patterns. However, in determining opposites, "...even the oldest deaf children did not perform as well as the youngest hearing children. ...deaf children were much slower or did not succeed at all in discovering the principles of opposites." (pp. 57-58)

Dualities and conflicts: Not only during transitions from a unitary perception to a conception of dualities but also at other times in our lives we experience conflicts when two parts are in competition with each other. We seem to have specific inherent difficulties when confronted with a choice of two items, a difficulty that is particularly verbal and that is exacerbated by uncertainty and stress.

An early but sometimes lingering, or occasional, confusion exists in discriminating right and left. Winnie-the-Pooh (Milne 1991b, p. 116) expresses this problem:

Pooh looked at his two paws. He knew that one of them was the right, and he knew that when you had decided which one of them was the right, then the other one was the left, but he never could remember how to begin.

A common example is when a person directs you to "Turn left", but contradicts his spoken error with a correct gesture to the right. A disastrous recent example is when the pilots 'inadvertently' switched off the wrong engine (and did not "assimilate all the indications of the engine display") -- causing the air crash on the M1 (Elliott 1990). The co-pilot, when asked which engine was at fault, is reported to have said, "It's the le..., it's the right one." (Another reversal was subsequently recommended to decrease fatalities: having the seats turned in the other direction, with passengers facing the rear of the aircraft.)

It is probable that oppositional terms are both primed in the fraction of a second when a statement is made, but that in the either-or situation when only one word can be said, it is the correct word -- or the negative (e.g. 'not left') -- that is suppressed. Levelt's (1989) analyses of speech errors indicate that the most frequent substitutions involve semantically related words: antonyms, which are mutually exclusive, and 'co-hyponyms' (e.g. fingers and toes). Freud (1914, p. 78) observed that

...we frequently interchange contrasting words; they are already associated in our speech consciousness; they lie very close together and are easily

incorrectly evoked.⁷

In sign languages, a sign that is distinguished from another by a single parameter is very likely to cause confusion and errors (Bellugi and Klima 1972, Klima and Bellugi 1979).⁸ With double articulation, signing one sign with one hand and another simultaneously with the other hand, it is possible to express conflicting emotions (ibid. and Appendix I). A head shake with a sign can indicate negation (e.g. with the hand signing 'understand' while the head supplies the 'not').⁹ More formally, negatives can be expressed by an additional sign of negation (e.g. 'don't', 'isn't') or by a sign affix -- as by continuing a sign but reversing its movement and direction (e.g. in 'don't-like' by bringing fingers together out from the chest and then turning the hand in the opposite direction with an opening 'throw-away' movement). Similarly, in ASL 'improve' becomes 'disimprove' simply by changing the direction of the movement (down versus up), and in BSL the left or right direction in which an index finger moves

⁷Numerous examples of antonym substitutions, two-part exchanges, and negative insertions or deletions -- called 'speech-blunders' and seen as obtruding thoughts and repressed ideas, i.e. as intentional accidents -- can be found in this 1914 book by Freud.

⁸For example, in American signs the pair 'mother' and 'father' differs only in place of execution (at the chin or forehead), 'family' and 'important' in the spatial plane of the movement (in an outward or an upward circle), 'airplane' and 'I-love-you' by whether the movement is continuous or static. (See Friedman [1977] for examples of other minimally differentiated sign pairs.) When being taught to sign, adults are able to indicate, with no hesitation, whether they prefer to learn such similar pairs together (to immediately differentiate them) or apart (to establish each within a separate context).

⁹When we speak, we may shake our heads while making a positive statement (or, less frequently, nod while making a negative statement), as though to underscore nonverbally the incredulity of a belief. (A famous example is when Martin Luther King, Jr, shook his head while he said, "I have a dream.") Note that in some cultures, head shakes and nods have other connotations. For instance, among Eskimos, the meanings are opposite those of English speakers (Farb 1977); among Greeks, a backwards 'nod' indicates denial, with the degree of disagreement intensified by simultaneous eye, hand, and tongue movements (Katerina Logotheti and Despina Papoudi, personal communication). Even among those who speak English, a series of nods can suggest more impatience than agreement (Pease 1981).

differentiates 'and' from 'but'. In signs used formerly by North American Indians, opposites were expressed by compounding 'no' to a root concept. For example, 'fool-no' was 'wise' and 'good-no' was 'bad' (Mallery 1978). With other types of manual contrast, tribes altered 'to tell the truth' (using one finger) to 'to tell a lie' (by using two fingers), and Cistercian monks are said to distinguish 'wise man' and 'fool' by placing either the thumb or the little finger on the tip of the nose (e.g. Teit 1978).

In spelling, it is pairs of letters that often are confused, e.g. 'ence' or 'ance, 'i' before or after 'e'. Letter reversals are common in children's early writing, especially of mirror pairs (e.g. of 'b' and 'd' or 'p' and 'q' -- rather than 'b' and 'p', and apparently there is not a confusion between the typed letters 'a' and 'e'). Also when a child is learning to speak, there can be difficulties caused by pairs of words that change depending upon who is speaking and where in time and space something is located: 'I' changes to 'you'; 'here' changes to 'there', 'this' to 'that', 'come' to 'go', 'bring' to 'take', 'today' to 'yesterday' (Clark and Clark 1977, Garvey 1984, Wood et al. 1986). Pooh has something to say about this perplexity too (Milne 1991a, p. 89):

...hardly anybody knows
If those are these or these are those.

In science, three-chain models failed to replicate the structure of DNA, but a two-chain model succeeded: The structure was a double helix, "right-handed with the two chains running in opposite directions" (Watson 1968, p. 200). Obviously, in philosophy there is the Cartesian dualism between mind and body, in psychology there are Jungian oppositions, and in literature there are Stevenson's Dr Jekyll

and Mr Hyde.¹⁰ In humour (as in novels and poems [Widdowson 1975] and magic [Moskowitz 1973]), an effect of contraries is to violate expectations, for example by substituting one meaning or action for another, and in jokes and puns to play upon double meanings (Kilgarrieff 1982).¹¹

About dualities in art, Bayley (1985, p. xviii) comments:

Art requires a dual awareness, or rather emphasizes as nothing else does the fact that our deepest and most important sensibility and powers of response are dual, needing fiction as truth and truth as fiction..."

Throughout history, in all areas of thought (note the 'ratio' in 'rationality'), and in the systems of man's affairs (e.g. with left wing versus right wing, credits versus debits, guilt versus innocence), so many polarities exist that it would be a challenge *not* to find themes of dualities.¹²

¹⁰What if every 'two' and 'half' and 'twice' and 'both', each '(n)either' and '(n)or', all comparative words, antonyms, similes, twice-repeated and palindromic phrases, and all double negatives and double *entendres* were deleted from the stories of Lewis Carroll (a.k.a. Charles Dodgson, who took double honours at Oxford, and had a stammer)? His Alice ("this curious child [who] was very fond of pretending to be two people" [Carroll 1987, p. 8]) could not have become smaller, or taller, or met a DoDo, or had her 'curiouser and curiouser' adventures in Wonderland. In its sequel, the looking glass would have had no other side for her to have gone through to, to where everything was 'contrariwise': There would have been no Tweedledum and Tweedledee, no White and Red Queens and Kings and Knights and Pawns, and no Haigha and Hatta (the King's two Messengers -- "One to come, and one to go. ...One to fetch, and one to carry." [Carroll 1984, p. 113]).

¹¹At a deeper level, humour is seen to be a reaction to adversity, as a recourse and alternative to action which would be unacceptable or which has failed. A salient example is minority groups, for whom humour allows an escape, a guised form of expression against antagonism (Joseph Hartog, personal communication; Freeman, Carbin, and Boese 1981).

¹²Many of the religious and superstitious ideas, and etymologies, associating the right side of the body with things that are 'good' and the left side with things that are 'bad' rationally may be false and anachronistic, yet they continue to have import -- not only to historians studying ancient Greek civilization or anthropologists and ethnologists studying 'primitive' cultures (e.g. Wheelwright 1959; Hertz, and others, 1973). Even at the end of this Twentieth Century, it is with our right hands that we are joined in holy matrimony, that we swear to tell nothing but the truth, and that we shake hands when introduced and when confirming agreement. (And still shirts for men and blouses for women are manufactured with a left-right buttoning difference.)

The ubiquity of antitheses must have some explanation. A simple one to posit (again following Darwin, who also had a stammer [Barsley 1970]) is an adaptation and survival benefit. Under some conditions, there are advantages from differentiation.

Contrasting and complementary specializations of the two halves of the human brain have been demonstrated when information is presented simultaneously to the two ears or to the two visual half-fields of normal subjects (Milner 1974). When two tasks are to be carried out simultaneously, then as a rule there is competition and a loss of efficiency. For example, experiments with contrasting acoustic stimuli, and with combined acoustic and tactile stimuli, have shown that "the intact person does have quite marked interference between tasks involving the two sides of the body" (Broadbent 1974, p. 35).¹³ It seems that it is possible for two functions to operate in parallel only exceptionally -- if there is a great contrast between the stimuli in one task so that a decision can be made with no uncertainty. Likewise, between the two hands, motoric conflict could be expected -- unless there is differentiation in how the two hands interact.

Dualities and complementarity: There is differentiation in the formation of signs (including those of Aborigines in the North Central Desert of Australia [Kendon 1988]). If both hands are active, a symmetry constraint specifies that their configuration and movement must be identical, and their orientation must be either identical or reciprocal (Battison 1974). Otherwise, for both hands to participate in the articulation of a sign, one hand will be active and dominant and the other will be static, serving as a base, and with its

¹³The White Queen knew this too. Her advice on how Alice could stop crying was to consider things: "'That's the way it's done,' the Queen said with great decision: 'nobody can do two things at once, you know.'" (Carroll 1984, p. 83)

handshape conforming to other restrictions.¹⁴ Furthermore, over time, signs characteristically assimilate toward greater symmetry, and to the configuration of the dominant hand (ibid.). As with symmetry, ipsilaterality of sign location also is stipulated: If a sign is not on the vertical midline of the body ('the main axis of symmetry'), generally the hand contacts the body on that same side.¹⁵ Altogether, these conditions of signs reduce complexity and allow the two hands to be used simultaneously, with greatest clarity and simplicity.

Studies of ontogenetic organization explain evolutions in the development of manual specialization. Allport and Vernon (1933) comment about movements early in life:

...gross musculature predominates over specific reflex action ... some infants as old as one year reach with both hands (that is, express the same tension with two limbs) when one would suffice. (p. 16)¹⁶

Much of the behavior in the young child is synkinetic; that is to say, his adaptive acts are accompanied by auxiliary movements. This seems to be a natural state in the process of transition from adjustment with the whole body to adjustment with single limbs. (p. 19)

Gesell and Ames (1947, p. 155) had a similar view about manual laterality, stating that it is "an extremely complex trait which is intricately bound up with the total action system of

¹⁴The handshape of the nondominant hand will be the same as the handshape of the active hand or else will be one from a limited set of six basic handshapes -- those that occur most frequently (accounting for 70% of all ASL signs), that appear to be among the first acquired and to be common to all sign languages, and that are comparatively less confusable and less limited in location (Battison 1974, Klima and Bellugi 1979, Boyes-Braem 1990).

¹⁵Some American signs are made with a hand contacting the contralateral and the ipsilateral side of the body, but only one regional sign has been identified that contacts only the contralateral side of the face (Battison 1974).

¹⁶Oléron (1964) made a similar comment about children's two-handed movements during transitivity experiments: They would simultaneously seize two objects of very unequal size rather than only the correct one with only one hand. When Montessori (1967b) observed how a three-year-old child "...took up at random two objects with both hands at the same time..." (p. 118), her comment about this 'functionally ambidextrous' act was: "This is very common among three- and 4-year-old children, but it later disappears." (p. 119)

the child." Interestingly, they observed bimanual movements to be predominant at two-and-a-half years -- "*a strong age for bilateral behavior... characteristically an age of 'opposite extremes'*" (p. 165, italics here and below in the original text). Their conclusion also is relevant:

The bipolarity which bisects the Emersonian universe, bisects also the organization of laterality in a growing organism. Two pairs of opposing trends are in mutual rivalry: bilaterality versus unilaterality, the right versus left. This gives rise to many inflections and combinations. ...They are in developmental flux. But the flux is channelized by virtue of *the principle of functional asymmetry*. ...effective attentional adjustments require an asymmetric focalization of motor set. (ibid., p. 174)

With electrophysiological procedures, significant relationships have been found between cognitive abilities and hemispheric asymmetries -- and, importantly, interhemispheric interactions (Thatcher, McAlaster, Lester, Horst, and Cantor 1983). Trends in the analyses of EEG (electroencephalogram) tests suggest a specific relationship between intelligence and hemispheric asymmetry: the higher the mental capacity and the intellectual achievement, the greater the neuronal differentiations and dissimilarities (shown both in maximal amplitude and minimal coherence in brain activity at paired sites within the hemispheres). Asymmetries more especially in the inter- than the intrahemispheric variables correlate with full-scale IQ scores. (The authors state that subtest differences, which have not yet been determined, might clarify the apparent differences in the direction of the asymmetries in left- and right-handers.)

With deaf and hearing subjects, evidence from EEG tests along with neuropsychological assessments (e.g. of cognitive functioning, motor development, impulsivity and activity levels) confirms the likelihood that early childhood deafness and sensory deprivation cause some degree of cerebral and cognitive reorganization that result in differences in processing styles (Wolff and Thatcher 1990).

In the Wolff and Thatcher study, two groups of deaf children

were compared with a group of hearing children. The deaf children, between the age of six and 16, were divided by etiology: whether their deafness (that for all was prelingual, bilateral, and in a severe to profound range) was of a genetic or a 'neurologically at risk' (NAR) origin. Both groups of deaf children had EEG patterns suggesting decreased, or 'less functionally developed', neuronal differentiation in specific areas of the left hemisphere and increased interneuronal differentiation in areas of the right hemisphere. Specific characteristics indicative of what could be a compensatory reorganization, a result of less auditory competition, and an 'enhancement' of aspects of right hemispheric functioning were more evident not only in the deaf children than in the hearing children but also among the deaf children: more in those with a genetic than a NAR etiology, and within the genetic group, more in those whose parents are deaf than those whose parents are hearing. (An additional finding was 'depressed frontal lobe functioning' in the deaf children, which Wolff and Thatcher thought could be associated with teachers' ratings of the children's impulsive, distractible, and disorganized behaviours.)¹⁷

¹⁷Whereas in the Thatcher et al. (1983) and Wolff and Thatcher (1990) studies brain activity was measured while the subjects were resting and had their eyes closed, in a study by Waldron, Farber, and Rose (1984), EEG patterns were obtained while the subjects were actively engaged in two visuospatial tasks and (to provide baseline data) when the subjects' attention was focussed on a dot. In this pilot study, fewer and older subjects were used, and Alpha and Beta activity was measured only at sites within Wernicke's area and corresponding points within the right hemisphere. Of their three groups of subjects, the oral deaf subjects were differentiated from both the hearing subjects and the deaf subjects who had signed since childhood. The oral deaf adults consistently showed greater activity in the right than in the left hemisphere, while the others showed either equal left and right activity (in one test) or greater left hemispheric activity (in the other test, which had a verbal element, and in the baseline condition). Under each condition, activity in both hemispheres was lowest in the oral deaf group and greatest in the signing deaf group. As both deaf groups had similar auditory deprivations (with the mean hearing loss of the oral deaf subjects 80 dB, versus 97 dB for the others), differences between them in cerebral function were presumed to relate to their different methods of communicating and to reflect differential development within linguistic areas of the left hemisphere.

Stage Three: Plurality and Synthesis

The earlier two stages appear to culminate in a final stage marked by integration, when subordination and coordination are achieved -- and when success in the sequencing tasks is ultimately achieved. Then entire patterns are perceived, parts are related to a whole configuration, multiple attributes are detected and irrelevant features are ignored. Manual actions are controlled, continuous, and systematically differentiated. For example, all placements will be made with one hand, all collections with the other. No longer are objects collected one-by-one; with a continuous motion, they are collected cumulatively across the board (and midline).

A speculation could explain both the association of left-handedness patterns with highest scores and the collectively lowest scores and the selectively high scores of children whose handedness patterns were the most mixed. Simply, it is that success on the sequencing tasks depends on collaborative functioning of the two hemispheres. Suggestive of this interhemispheric communication are two facts: that, in general, left-handers, including left-handed children (Longoni and De Gennaro 1992), have less exclusive left-hand preferences, and a more bilateral hemisphericity, than right-handers (who have stronger right-hand preferences and express greater hemispheric asymmetry); that in these sequencing tasks, successful right-handed children elected to use their left hands in ways that were controlled and systematic, while others, who did not differentiate their manual actions for specific functions or perceive relationships *among* the objects, did not succeed.

Six references support this hypothesis. Each stresses the interrelationships and influence of one complementary part upon the other and of several parts upon the whole, and each recognizes the effect of different conditions upon development and learning.

1. Zajonc (1980) emphasizes the transformations of thoughts by feelings. Believing in the primacy of

impressions and in the precedence of subjectivity to objectivity, he sees how cognitions are accompanied and qualified by emotional components, how meanings are affected by and are 'saturated' with affect.

2. Kephart's (1971) perspective, from working with children who are 'slow learners', is that sensory and time-space translations are crucial to both motor and mental development. Through fine and gross motor activities and explorations, concepts of body image improve, activation and innervation are balanced, information that is perceived simultaneously is integrated into sequential movements, and specifics are related to form generalizations. Experiences and cognitions become 'welded', and neither movement patterns nor learning is restricted.
3. Blythe and McGlown (1981) have also recommended motor-training programmes to remediate 'specific learning difficulties'. They associate visual-perceptual problems, visual-motor integration difficulties, aberrant motor patterns, and crossed or ambiguous laterality with abnormal reflex patterns. In their view, primitive and postural reflexes have been retained, rather than inhibited and transferred by the neocortex into a mature reflex system, and that this results in impaired cognitive processing abilities, educational difficulties, and the possibility of labile emotional behaviours.
4. Sacks (1990) applies Goldberg's (e.g. 1989) theory of interhemispheric collaboration and complementarity to cognitive strategies of deaf people. Theoretically, there are shifts from initial right-hemispheric reception and processing of novel information to left-hemispheric control for the processing of familiar codified information. The implication is that for many deaf people, language is not at such an automatic stage for the left hemisphere to function effectively:

Early language acquisition, whether speech or Sign, seems to kindle the linguistic powers of the left hemisphere; and deprivation of language, partial or absolute, seems to retard development and growth in the left hemisphere.
(p. 105)

5. In their experiments to improve the reading abilities of two different types of dyslexic children, Bakker, Bouma, and Gardien (1990) combine three theories: a) that the reading process in particular shifts from being mediated predominantly by the right hemisphere to becoming more left-hemispheric; b) that the reading errors of 'perceptual' and 'linguistic' dyslexics relate to their different strategies and deviant hemispheric development; and c) that the use of one hand will stimulate the contralateral hemisphere. They report that through tactile training, the one group improved in fluency and the other in accuracy.

6. Of great relevance are the associations Gladstone and Best (1985) have seen between callosal patients and dyslexic children. Several of their similar symptoms are common also among deaf people: a higher incidence of left-handedness (Bonvillian et al. 1982), greater distractibility (e.g. Meadow 1980), inconsistency and variability of responses (Conrad 1975). Another analogy relating not only to the deaf children in the thesis studies is impaired bimanual coordination. An anatomical basis for the differences of these groups, or subgroups, and the general population is postulated: a left-hemispheric dysfunction and poor interhemispheric collaboration.

Therefore, a Stage Three synthesis -- with the specialized functions of each hemisphere in part separate and in part integrated (as shown in the diagramme at the beginning of this chapter) -- is thought to be necessary for normal, and optimal, development. The findings of Annett (e.g. 1990, cited in Chapter 1) also would be supported by such a possibility: The higher-functioning children in her studies (who were not hearing-impaired and were of an age beginning at the end age of the hearing children in the Main Study of this thesis, i.e. *from* five to 11 years old) were the children whose handedness was not at either extreme but at the centre of the laterality continuum. It would seem that our two hemispheres have been rather well designed -- that when they reach a stage of functioning independently and together, our attainments are greatest.

EDUCATIONAL IMPLICATIONS

If these interpretations are valid and can be substantiated by future research, we cannot be blithe about our educational policies and practices. Realities we confront are economic recessions in Great Britain and in the United States, decreasing numbers and geographic dispersion of deaf children, and laws enacted in both countries that mandate integration of deaf with hearing children in our school systems. We no longer have either the fiscal resources or the jurisdiction to maintain special centralized schools for the deaf (except with repeated battles and temporary exemptions [Constance Mace, personal communication]). Yet our responsibility as educators

is to meet the needs of individual deaf and hearing children alike, even when they are not alike, and to provide support and resource services for the children and their families, without allowing limitations of funds available to limit the possibilities of the children's mental and emotional development and academic achievements.

A positive repercussion of mainstreaming would be if the children who are alike -- those deaf and hearing children whose mode of thinking is more typically 'lateral' and right-hemispheric -- could receive recognition and compatible instruction that would change cycles of failure into spirals of success.

Programs are beginning to incorporate mediation techniques such as those developed by Feuerstein (referred to in Appendix D). Feuerstein's (1980) dynamic approach combines assessment of capacities with methods to accelerate learning. Within a stimulus-human-organism-response framework, mediators provide input and elaboration to change and reverse past experiential deficits, to modify mutable behaviour patterns, to intervene in the patterns of rejection and compulsive repetitions, to focus perception and attention (ibid., Sharron 1987a and 1987b). By making comparisons and analogies, integrating information, applying the known to the unknown, anticipating consequences and visualizing the future, and by balancing inhibition and initiation, deferring gratification, and realizing intermediate alternatives to passivity and impulsivity, the children develop thinking strategies, and impaired skills are repaired; through interactions, they become competent, knowledgeable of their heritage, and aware of their abilities "to interpret and act upon the world" (Sharron 1987a, p. 49).

Programs have begun to integrate subjects and approaches and to develop a child's weaker skills through his abilities and natural learning propensities. A flexible approach that combines methods for different children and for the same child but at different times is difficult to implement, but has been

shown to succeed.

Abstracts from a recent conference titled 'Literacy Without Frontiers' (UKRA 1991) describe current trends in education today, trends away from 'fragmentation' and toward comprehension. Changes within the classroom are seen to represent the modern 'multicultural Europe' and the wider 'interdependent world'. Vogue terms, and attempts, are 'interdisciplinary', 'multisensorial', 'metacognitive'. With team teaching approaches and computer-assisted programmes, basic skills are taught as strands around themes. A 'range of genres' replaces isolated subjects, so that reading instruction is related to writing, listening and speaking skills -- all together comprising the Language Arts. Emphasis is on 'text within context', and the goal is for 'Whole Literacy'. While the abstracts report not only the popular philosophy but also the practices, and experiments, in schools in many countries, there is a possibility that we are mistaking a pendulum swing for a progression. We cannot but strive to provide everything for each and all children but must be prepared for the costs of ideals we cannot realize, for the cacophony of a symphony if its score cannot be played.

Regarding *music*, Robbins and Robbins (1980) have developed a music education programme for hearing-impaired children from the age of three to 16, including those with profound losses and those with multiple handicaps. The Robbins observed how through active learning and holistic involvement, and with signs as well as speech, deaf students have been taught to sing and to play a variety of musical instruments, to combine movements with music and music with games and dances, to perceive contrasts of rhythms (e.g. changes of pitch, duration, tempo, and intensity dynamics) and to interrelate parts to whole patterns and phrases to pauses, to achieve balance and bilateral capabilities (including crossing the body midline), and to read notation symbols (repeating unit counts and following both musical scores and the conductor).

With instruction progressing in stages from the simple to the complex (e.g. from single tones to patterns of several notes played in sequence or simultaneously, from isolated movements to alternate and combined movements), with each child challenged at his own level in structured explorations and creative improvisations, and by performing before audiences, the students developed numerous skills: Their movements became controlled and coordinated; their concentration increased and their auditory attention span was continually lengthened; their auditory sensitivities and perceptions, recognitions and discriminations, and memory were expanded, and were synthesized with visual, motor, and kinaesthetic information; their understanding and appreciation of music were heightened, and there were indications that their speech improved. There was a realization of personal competencies, of what each child could do, along with the pleasure of interdependent, shared musical accomplishments. Through an 'inner growth process of awareness' and by 'discovering music through making it', the whole of the musical experience of the children was seen to be greater than the sum of its parts.

A science curriculum developed for deaf students, described by Bryan (1969), is based on sequential 'process' skills and direct experiences with materials that are individualized and utilize a variety of media. Goals are for laboratory activities to be coordinated with textual materials, for facts to be related to principles, and for an understanding of scientific concepts to be developed along with independent inquiry and an acceptance of responsibility for learning.

To improve deaf children's reading abilities, and overcome a fourth-grade plateau in reading proficiency, Ewoldt (1981) advocates a 'whole story' approach. Having analyzed the reading strategies of a few deaf children between the ages of seven and 17, she concluded the deaf children benefitted from redundancies within the text when given entire stories, rather than isolated paragraphs, to read and retell (and when given cloze passages with repeated sentence patterns). Also by being allowed to read the stories without interruptions and to

fingerspell the printed words or interpret them into signs or pantomimes, in spite of difficult syntactic structures and unfamiliar words, the children were able to integrate cueing systems and make inferences and predictions, and to comprehend the meaning of the stories.

The trend, then, both in general education and in special education for deaf children, is similar: away from fragmentation and towards integration. With *children* (not only academic subjects) integrated, advantages could be realized -- depending on the linguistic competence of the deaf children when they enter integrated classrooms (as well as attitudes and provisions mentioned in Appendix D). This would depend on the kind and quality of preschool programmes.

A specific recommendation would be to institute and implement infant and nursery programs designed and staffed by a majority of deaf adults. This recommendation is based on the belief that both subjectively and objectively deaf people know their own needs best, that hearing parents' competencies and knowledge of deafness can be broadened through contacts with deaf adults, and, in agreement with the view of modern oralists (e.g. Clark 1978 and 1989, and Morag Turner, personal communication), that a 'natural' approach is most beneficial for maximizing a deaf child's learning. Emphasis would be on visual aspects and strengths, through which weaker auditory and articulatory skills could be developed. The early communicative competence of the children could only foster their abilities to later acquire English language skills and achieve literacy -- and receive the presumed benefits of both visual and verbal modes of thinking -- before it might be too late (Conrad 1979).

The argument of costs could be countered by the probability of long-term *savings*, such as have been documented for preschool programmes by the High/Scope Educational Research Foundation (Berrueta-Clement, Schweinhart, Barnett, Epstein, and Weikart 1984, p. 1):

Over the lifetimes of the participants, preschool is estimated to yield economic benefits with an estimated present value that is over seven times the cost of one year of the program.

FURTHER RESEARCH

1. Nonlinear arrays: The three tasks that differentiated the sequencing skills of the deaf and the hearing children all required a left-to-right arrangement of the materials. As this feature was absent in the other three tasks, on which the performance of the deaf and hearing children was similar, it may have been an influencing factor. To analyze it separately, different spatial arrangements could be investigated with these same materials. For example, the picture cards might instead be put in a vertical line, with the first card at the bottom and the last at the top (corresponding to the temporal planes in sign language and complementing children's early central focus).

2. A one-handed condition: A small experiment was conducted with two children to see if there could be improvements when a child uses only his preferred hand to sequence objects. The results, reported in Appendix E, indicate superior performance under the one-handed condition. Theoretically, a more exclusive use of one hand could eliminate potential conflict between the hands, and the hemispheres, and could induce compatible left-hemispheric processing -- especially if only the right hands of right-handed children are active and if the children verbalize while doing the sequencing tasks.

Another way to bias movements would be to use a frame which could be positioned at the child's left. This off-centre positioning also might reduce midline conflicts while encouraging either contralateral right-handed movements or more continuous left-handed movements.

These are but two possible ways we could intervene to give structure to how a child uses his hands. However, even without formal research, careful observation of children's

spontaneous actions itself could give credence to the information they provide: clues to developmental stages and indications of problems.

SUMMARY

The conclusions support the idea that through language a left-hemispheric organization can be encouraged. A spoken language, composed of sequential elements, seems adaptively designed for left-hemispheric processing; likewise fingerspelling and reading will be conducive to left-hemispheric processing. However, a language system established through unstressed relationships and successful intermodal communications, within a 'critical period' and with regard to 'readiness', could be the basis -- not substitution -- for later development of speech, fingerspelling, and reading. A goal would be for deaf children to have bilingual competence, with bilateral coordination.

It is my conviction that we must concentrate our attention and resources on providing linguistic and other experiences for deaf children which will enhance, and not leave to chance, complementary development of left hemispheric thinking capacities. Then we could hope for some attainments and appreciations on the one hand, some others on the other hand, and *most* then on both hands.

REFERENCES

- Allen, T.E. (1986) Patterns of academic achievement among hearing impaired students: 1974 and 1983. Chapter 8, pp. 161-206, in A.N. Schildroth and M.A. Karchmer (Eds), *Deaf Children in America*. San Diego: College-Hill Press.
- Allport, G.W., and P.E. Vernon (1933) *Studies in Expressive Movement*. New York: Macmillan.
- Annett, M. (1985) *Left, Right, Hand and Brain: The Right Shift Theory*. London: Erlbaum.
- (1990) Left and right handedness and intelligence. *MRC News*, No. 46: 12-13.
- (1992) Phonological processing and right minus left hand skill. *The Quarterly Journal of Experimental Psychology* **44A** (1): 33-46 (January).
- and M. Manning (1989) The disadvantages of dextrality for intelligence. *British Journal of Psychology* **80**: 213-226.
- (1990a) Reading and a balanced polymorphism for laterality and ability. *Journal of Child Psychology and Psychiatry* **31**: 511-529.
- (1990b) Arithmetic and laterality. *Neuropsychologia* **28**(1): 61-69.
- Arnold, P. (1983) Does pure oralism cause atrophy of the hearing-impaired child's brain? *Volta Review* **85**(4): 229-234 (May).
- Ashton-Warner, S. (1963) *Teacher*. New York: Simon and Schuster.
- Ayres, A.J. (1974) *Sensory Integration and Learning Disorders*. Los Angeles: Western Psychological Services.
- Baker, C., and D. Cokely (1980) *American Sign Language: A Teacher's Resource Text on Grammar and Culture*. Silver Spring (MD): T.J. Publishers.
- Bakker, D.J., A. Bouma, and C.J. Gardien (1990) Hemisphere-specific treatment of dyslexia subtypes: A field experiment. *Journal of Learning Disabilities* **23**(7): 433-482 (August/September).
- Barsley, M. (1970) *Left-handed Man in a Right-handed World*. London: Pitman.
- Battison, R. (1974) Phonological deletion in American Sign Language. *Sign Language Studies* **5**: 1-19 (October).

- Bayley, J. (1985) Introduction, pp. xi-xx, in E. Wind, Art and Anarchy (Third Edition). London: Duckworth.
- Beaton, A. (1985) Left Side, Right Side: A Review of Laterality Research. London: Batsford.
- Bellugi, U., and E.S. Klima (1972) The roots of language in the sign talk of the deaf. *Psychology Today* 6: 61-76 (June).
- , H. Poizner, and E.S. Klima (1983) Brain organization for language: clues from sign aphasia. *Human Neurobiology* 2: 155-170.
- Beloff, H. (1988) The Eye and the Me: self-portraits of eminent photographers. *Philosophical Psychology* 1(3): 295-311.
- Berrueta-Clement, J.R., L.J. Schweinhart, W.S. Barnett, A.S. Epstein, and D.P. Weikart (1984) Changed Lives: The Effects of the Perry Preschool Program on Youths Through Age 19 (Monograph Number 8). Ypsilanti (MI): High/Scope Educational Research Foundation.
- Binet, A., and T. Simon (1910) An investigation concerning the value of the oral method. *American Annals of the Deaf* 55: 4-33. [Reprinted in translation from *l'Année psychologique* xv: 373-396, 1909.]
- (1980) The Development of Intelligence in Children. Nashville (Tenn.): Williams Printing Company. [Marginal notes by Lewis M. Terman.]
- Blair, F.X. (1957) A study of the visual memory of deaf and hearing children. *American Annals of the Deaf* 102: 254-263.
- Blennerhassett, L. (1990) Intellectual assessment. Chapter 10, pp. 255-280, in D.F. Moores and K.P. Meadow-Orlans (Eds), Educational and Developmental Aspects of Deafness. Washington, D.C.: Gallaudet University Press.
- Blythe, P., and D.J. McGlown (1981) An organic basis for educational difficulties. *Momentum* 6(3): 1-15 (Autumn).
- Bonvillian, J.D., and K.E. Nelson (1978) Development of sign language in autistic children and other language-handicapped individuals. Chapter 7, pp. 187-212, (in) P. Siple (Ed.), Understanding Language Through Sign Language Research. New York: Academic Press.
- , M.D. Orlansky, and J.B. Garland (1982) Handedness patterns in deaf persons. *Brain and Cognition* 1: 141-157.
- Boyes-Braem, P. (1990) Acquisition of the handshake in

- American Sign Language: A preliminary analysis. Chapter 9, pp. 107-127, in V. Volterra and C.J. Erting (Eds), *From Gesture to Language in Hearing and Deaf Children*. Berlin: Springer-Verlag.
- Brain, W.R. (1945) Speech and handedness. *Lancet* 2: 837-842 (December 29).
- Broadbent, D.E. (1974) Division of function and integration of behavior. Chapter 3, pp. 31-41, in F.O. Schmitt and F.G. Worden (Eds-in-Chief), *The Neurosciences: Third Study Program*. Cambridge (MA): MIT Press.
- Brown, S.C. (1986) Etiological trends, characteristics, and distributions. Chapter 2, pp. 33-54, in A.N. Schildroth and M.A. Karchmer (Eds), *Deaf Children in America*. San Diego: College-Hill Press.
- Bruner, J.S. (1974) *Beyond the Information Given: Studies in the Psychology of Knowing* (J.M. Anglin, Ed.). London: George Allen and Unwin. [Eye, hand, and mind, Chapter 15, pp. 270-279, reprinted from D. Elkind and J.H. Flavell (Eds), *Studies in Cognitive Development: Essays in Honor of Jean Piaget*. Oxford: Oxford University Press, 1969.]
- Bryan, F.R. (1969) Science curriculum and individualized instruction for deaf students. Report of the Proceedings of the 44th Meeting of the Convention of American Instructors of the Deaf. Berkeley (CA): California School for the Deaf, Berkeley.
- Burt, C. (1958) *The Backward Child* (Fourth Edition). London: University of London Press.
- Carroll, L. (1984) *Through the Looking Glass and What Alice Found There*. London: Puffin Books. [Originally published in 1872.]
- (1987) *Alice in Wonderland*. London: Dent. [Originally published in 1865, titled *Alice's Adventures in Wonderland*.]
- Cermak, S.A., E.J. Quintero, and P.M. Cohen (1980) Developmental age trends in crossing the body midline in normal children. *American Journal of Occupational Therapy* 34(5): 313-319.
- Chambers Twentieth Century Dictionary (1979). A.M. Macdonald (Ed.). Edinburgh: Chambers.
- Charlesworth, W.R., and M.A. Kreutzer (1973) Facial expressions of infants and children. Chapter 3, pp. 91-168, in P. Ekman (Ed.), *Darwin and Facial Expression: A Century of Research in Review*. New York: Academic Press.

- Chevalier-Skolnikoff, S. (1989) Spontaneous tool use and sensorimotor intelligence in *Cebus* compared with other monkeys and apes. *Behavioral and Brain Sciences* **12**(3): 561-627 (September).
- Clark, H.H., and E.V. Clark (1977) *Psychology and Language: An Introduction to Psycholinguistics*. New York: Harcourt Brace Jovanovich.
- Clark, M.H. (1978) Preparation of deaf children for hearing society. *The Teacher of the Deaf: Journal of the British Association of Teachers of the Deaf* **2**(5): 146-154 (September).
- (1989) *Language Through Living for Hearing-impaired Children*. London: Hodder and Stoughton.
- Cokely, D., and C. Baker (1980) *American Sign Language: A Student Text (Units 1-9)*. Silver Spring (MD): T.J. Publishers.
- Conrad, R. (1971) The chronology of the development of covert speech in children. *Developmental Psychology* **5**(3): 398-405.
- (1975) Commentary. Chapter 7, pp. 139-142, in N. O'Connor (Ed.), *Language, Cognitive Deficits, and Retardation*. London: Butterworth.
- (1976) Matters arising. Chapter 21, pp. 146-155, in P. Henderson (Ed.), *Methods of Communication Currently Used in the Education of Deaf Children (Seminar Papers)*. London: Royal National Institute for the Deaf.
- (1979) *The Deaf Schoolchild: Language and Cognitive Function*. London: Harper and Row.
- Corballis, M.C. (1983) *Human Laterality*. New York: Academic Press.
- (1992) *The Lopsided Ape: Evolution of the Generative Mind*. Oxford: Oxford University Press.
- Corina, D.P., J. Vaid, and U. Bellugi (1992) The linguistic basis of left hemisphere specialization. *Science* **255**: 1258-1260 (6 March).
- Cowley, M. (1967) Introduction, pp. 1-15, in S. Anderson (Author), *Winesburg, Ohio*. London: Jonathan Cape.
- Cox, M. (1978) *Coding the Therapeutic Process: Emblems of Encounter, A Manual for Counsellors and Therapists*. Oxford: Pergamon Press.
- Dalby, J.T., D. Gibson, V. Grossi, and R.D. Schneider (1980) Lateralized hand gesture during speech.

Journal of Motor Behavior 12(4): 292-297.

- de Bono, E. (1967) The Use of Lateral Thinking. London: Jonathan Cape.
- Doherty, J.E. (1985) The effects of sign characteristics on sign acquisition and retention: An integrative review of the literature. AAC Augmentative and Alternative Communication 1(3): 108-121.
- Donaldson, M. (in collaboration with D. Withrington) (1963) A Study of Children's Thinking. London: Tavistock.
- (1984) Children's Minds. London: Flamingo/Fontana.
- Doré-Lamontagne, L. (1976) Aspects of Strip-Cartoon Interpretation in 5 to 7-Year Old Children. Unpublished Ph.D. Thesis, University of Edinburgh.
- Edwards, B. (1979) Drawing on the Right Side of the Brain: A Course in Enhancing Creativity and Artistic Confidence. Los Angeles: J.P. Tarcher.
- Elliott, H. (1990) M1 crash report calls for reverse seating research. The Times, p. 1 (3 September).
- Epstein, H.T. (1986) Stages in human brain development. Developmental Brain Research 30: 114-119.
- Evans, L. (1982) Total Communication: Structure and Strategy. Washington, D.C.: Gallaudet College Press.
- Ewoldt, C. (1981) A psycholinguistic description of selected deaf children reading in Sign language. Reading Research Quarterly XVII(1): 58-89.
- Fadely, J., and V. Hosler (1979) Understanding the Alpha Child at Home and School: Left and Right Hemispheric Function in Relation to Personality and Learning. Springfield (IL): Thomas.
- Farb, P. (1977) Word Play: What Happens When People Talk. London: Coronet Books/Hodder and Stoughton.
- Feuerstein, R. (in collaboration with Y. Rand, M.B. Hoffman, and R. Miller) (1980) Instrumental Enrichment: An Intervention Program for Cognitive Modifiability. Baltimore: University Park Press.
- Fraiberg, S.H. (1959) The Magic Years: Understanding and Handling the Problems of Early Childhood. London: Methuen.
- Freeman, R.D., C.F. Carbin, and R.J. Boese (1981) Can't Your Child Hear? A Guide for Those Who Care about Deaf Children. London: Croom Helm.

- Freud, S. (1914) *Psychopathology of Everyday Life*. London: T. Fisher Unwin.
- Friedman, L.A. (1977) Introduction, pp. 1-9, in L.A. Friedman (Ed.), *On the Other Hand: New Perspectives on American Sign Language*. New York: Academic Press.
- Frishberg, N. (1985) Dominance relations and discourse structures. [Unnumbered] Chapter, pp. 79-90, in W. Stokoe and V. Volterra (Eds), *SLR '83 (Sign Language Research)*. Silver Spring (MD): Linstok Press.
- Fundudis, T., I. Kolvin, and R.F. Garside (1979) Review of literature: Intellectual and language issues. Chapter 9, pp. 131-145, in T. Fundudis, I. Kolvin, and R.F. Garside (Eds), *Speech Retarded and Deaf Children: Their Psychological Development*. London: Academic Press.
- Furth, H.G. (1973) *Deafness and Learning: A Psychosocial Approach*. Belmont (CA): Wadsworth.
- Garvey, C. (1984) *Children's Talk*. London: Fontana Paperbacks.
- Geiger, G., and J.Y. Lettvin (1987) Peripheral vision in persons with dyslexia. *The New England Journal of Medicine* **316**(20): 1238-1243 (14 May).
- Gesell, A., and L.B. Ames (1947) The development of handedness. *Journal of Genetic Psychology* **70**: 155-175.
- Gibson, C. (1988) The impact of early developmental history on cerebral asymmetries: Implications for reading ability in deaf children. Chapter 22, pp. 591-604, in D.L. Molfese and S.J. Segalowitz (Eds), *Brain Lateralization in Children: Developmental Implications*. New York: Guilford Press.
- and S.J. Segalowitz (1986) The impact of visual-spatial information on the development of reading proficiency in deaf children. Chapter 10, pp. 215-227, in J.-L. Nespoulous, P. Perron, and A.R. Lecours (Eds), *The Biological Foundations of Gestures: Motor and Semiotic Aspects*. Hillsdale (NJ): Lawrence Erlbaum Associates.
- Gladstone, M., and C.T. Best (1985) Developmental dyslexia: The potential role of interhemispheric collaboration in reading acquisition. Chapter 4, pp. 87-118, in C.T. Best (Ed.), *Hemispheric Function and Collaboration in the Child*. Orlando: Academic Press.

- Goldberg, E. (1989) The gradiential approach to neocortical functional organization. *Journal of Clinical and Experimental Neuropsychology* **11**(4): 489-517 (Summer).
- Goldin-Meadow, S., and C. Mylander (1984) Gestural communication in deaf children: The effects and noneffects of parental input on early language development. *Monographs of the Society for Research in Child Development* **49**(3-4, Serial No. 207).
- Gordon, H.W. (1986) The Cognitive Laterality Battery: Tests of specialized cognitive function. *International Journal of Neuroscience* **29**: 223-244.
- Grant, R. (1985) The dyslexic child: Eye control when reading. *Optician* **190**: 11 and 19 (8 November).
- Grieve, R. (1990) Children's Awareness. Chapter 9, pp. 156-171, in R. Grieve and M. Hughes (Eds), *Understanding Children: Essays in Honour of Margaret Donaldson*. Oxford: Basil Blackwell.
- Hampson, E., and D. Kimura (1984) Hand movement asymmetries during verbal and nonverbal tasks. *Canadian Journal of Psychology* **38**(1): 102-125 (March).
- Hart, B.O. (1963) *Teaching Reading to Deaf Children*. Washington, D.C.: Alexander Graham Bell Association for the Deaf.
- Hartog, J. (1974) A transcultural view of sibling rank and mental disorder. *Acta Psychiatrica Scandinavica* **50**: 33-49.
- Hepper, P.G., S. Shahidullah, and R. White (1991) Handedness in the human fetus. *Neuropsychologia* **29**(11): 1107-1111.
- Hermelin, B.M., and N. O'Connor (1975a) Seeing, speaking, and ordering. Chapter 7, pp. 129-138, in N. O'Connor (Ed.), *Language, Cognitive Deficits, and Retardation*. London: Butterworth.
- (1975b) The recall of digits by normal, deaf and autistic children. *British Journal of Psychology* **66**(2): 203-209 (May).
- Hertz, R. (1973) The pre-eminence of the right hand: A study in religious polarity. Chapter 1, pp. 3-31, in R. Needham (Ed.), *Right and Left: Essays on Dual Symbolic Classification*. Chicago: The University of Chicago Press. [Originally published in 1909; translated by R. Needham.]
- Hewes, G.W. (1976) The current status of the gestural theory of language origin. *Annals of the New York Academy of Sciences* **280**: 482-504.

- Hicks, R.E., and M. Kinsbourne (1978) Human handedness. Chapter 14, pp. 523-549, in M. Kinsbourne (Ed.), *Asymmetrical Function of the Brain*. Cambridge: Cambridge University Press.
- Hiskey, M.S. (1956) A study of the intelligence of deaf and hearing children through a comparison of performances on the separate standardizations of the Nebraska Test of Learning Aptitude. *American Annals of the Deaf* **101**: 329-339.
- (1966) *Hiskey-Nebraska Test of Learning Aptitude: Manual*. Lincoln (NB): Union College Press.
- Hoemann, H.W., and R. Lucafo (1980) *I Want to Talk: A Child Model of American Sign Language*. Silver Spring (MD): National Association of the Deaf.
- Hoff, B. (1982) *The Tao of Pooh*. London: Methuen.
- Hoosain, R., and L.-P. Shiu (1989) Cerebral lateralization of Chinese-English bilingual functions. *Neuropsychologia* **27**(5): 705-712.
- Ingram, D. (1975a) Motor asymmetries in young children. *Neuropsychologia* **13**(1): 95-102.
- (1975b) Cerebral speech lateralization in young children. *Neuropsychologia* **13**(1): 103-105.
- Kaufman, A.S., and N.L. Kaufman (1983) *K-ABC: Kaufman Assessment Battery for Children: Interpretive Manual*. Circle Pines (MN): American Guidance Service.
- Kellogg, R. (1969) *Analyzing Children's Art*. Palo Alto (CA): National Press Books.
- Kelly, R.R., and C. Tomlinson-Keasey (1976) Information processing of visually presented picture and word stimuli by young hearing-impaired and normal-hearing children. *Journal of Speech and Hearing Research* **19**: 628-638.
- (1977) Hemispheric laterality of deaf children for processing words and pictures presented to the hemifields. *American Annals of the Deaf* **122**: 525-535 (December).
- Kendon, A. (1986) Current issues in the study of gesture. Chapter 1, pp. 23-47, in J. Nespoulous, P. Perron, and A. Roch (Eds), *The Biological Foundations of Gestures: Motor and Semiotic Aspects*. Hillsdale (N.J.): Lawrence Erlbaum Associates.
- (1988) *Sign Languages of Aboriginal Australia: Cultural, Semiotic and Communicative Perspectives*. Cambridge: Cambridge University Press.

- Kephart, N.C. (1971) *The Slow Learner in the Classroom*. Columbus (OH): Charles E. Merrill.
- Kilgarriff, M. (1982) *1000 More Jokes for Kids*. London: Ward Lock.
- Kimura, D. (1973a) Manual activity during speaking--I. Right-handers. *Neuropsychologia* 11: 45-50.
- (1973b) Manual activity during speaking--II. Left-handers. *Neuropsychologia* 11: 51-55.
- (1981) Neural mechanisms in manual signing. *Sign Language Studies* 33: 291-312.
- (1990) How special is language? *Sign Language Studies* 66: 79-84 (Spring). [Book review of H. Poizner, E.S. Klima, and U. Bellugi (1987); reprinted from *Language and Speech* 31(4): 375-378, 1988.]
- Kinsbourne, M., and M. Hiscock (1983) The normal and deviant development of functional lateralization of the brain. Chapter 4, pp. 157-280, in M.M. Haith and J.J. Campos (Eds), *Handbook of Child Psychology* (Fourth Edition). New York: Wiley.
- Klima, E.S., and U. Bellugi (with others) (1979) *The Signs of Language*. Cambridge (MA): Harvard University Press.
- Kluwin, T.N. (1981) The grammaticality of manual representations of English in classroom settings. *American Annals of the Deaf* 126(4): 417-421.
- Lebrun, Y. (1985) Sign aphasia. *Language Sciences* 7(1): 143-154 (April).
- and C. Leleux (1986) Central communication disorders in deaf signers. Chapter 13, pp. 255-269, in J.-L. Nespoulous, P. Perron, and A.R. Lecours (Eds), *The Biological Foundations of Gestures: Motor and Semiotic Aspects*. Hillsdale (NJ): Lawrence Erlbaum Associates.
- Lenneberg, E.H. (1967) *Biological Foundations of Language*. New York: John Wiley and Sons.
- Levelt, W.J.M. (1980) On-line processing constraints on the properties of signed and spoken language. Chapter, pp. 141-160, in U. Bellugi and M. Studdert-Kennedy (Eds), *Signed and Spoken Language: Biological Constraints on Linguistic Form*. Dahlem Konferenzen. Berlin (March). Weinheim: Verlag Chemie.
- (1989) *Speaking: From Intention to Articulation*. Cambridge (MA): MIT Press.

- Ling, D. (Ed.) (1984) *Early Intervention for Hearing-Impaired Children: Total Communication Options*. San Diego: College Hill Press.
- Lomas, J., and D. Kimura (1976) Interhemispheric interaction between speaking and sequential manual activity. *Neuropsychologia* **14**(1): 23-33.
- Longman Dictionary of the English Language (1984). Burnt Mill: Longman.
- Longoni, A.M., and L. De Gennaro (1992) Reliability of a handedness performance test in right and left handed children: a research note. *Journal of Child Psychology and Psychiatry* **33**(4): 771-778 (May).
- Lowenfeld, V., and W.L. Brittain (1987) *Creative and Mental Growth* (Eighth Edition). New York: Macmillan.
- Lowenthal, D., and P.C. Wason (1977) Academics and their writing. *Times Literary Supplement*, p. 781 (24 June).
- Lurie, A. (1984) *Foreign Affairs*. New York: Avon.
- Mackworth, N.H., and J.S. Bruner (1970) How adults and children search and recognize pictures. *Human Development* **13**: 149-177.
- MacLeish, A. (1935) *Poems*. London: Boriswood.
- MacNeilage, P.F., M.G. Studdert-Kennedy, and B. Lindblom (1984) Functional precursors to language and its lateralization. *American Journal of Physiology* **246**: R912-R914.
- (1987) Primate handedness reconsidered. *Behavioral and Brain Sciences* **10**(2): 247-303 (June).
- Mallery, G. (1978) Introduction to the study of sign language among the North American Indians as illustrating the gesture speech of mankind. In D.J. Umiker-Sebeok and T.A. Sebeok (Eds), *Aboriginal Sign Languages of the Americas and Australia, Volume 1* (pp. 5-70). New York: Plenum Press. [Originally published in 1880.]
- McGuinness, D. (1985) *When Children Don't Learn: Understanding the Biology and Psychology of Learning Disabilities*. New York: Basic Books.
- McKeever, W.F., H.W. Hoemann, V.A. Florian, and A.D. VanDeventer (1976) Evidence of minimal cerebral asymmetries for the processing of English words and American Sign Language in the congenitally deaf. *Neuropsychologia* (14): 413-423.

- McNeill, D. (1985a) So you think gestures are nonverbal? *Psychological Review* **92**(3): 350-371.
- (1985b) Temaniotics, or the wisdom of the hands. Paper presented at the Eastern States Conference on Linguistics. Buffalo, New York (October).
- (1992) *Hand and Mind: What Gestures Reveal About Thought*. Chicago: University of Chicago Press.
- Meadow, K.P. (1980) *Deafness and Child Development*. Berkeley: University of California Press.
- Menyuk, P. (1971) *The Acquisition and Development of Language*. Englewood Cliffs (NJ): Prentice-Hall.
- Milne, A.A. (1991a) *Winnie-the-Pooh*. London: Mammoth. [Originally published in 1926.]
- (1991b) *The House at Pooh Corner*. London: Mammoth. [Originally published in 1928.]
- Milner, B. (1974) Hemispheric specialization: Scope and limits. Chapter 8, pp. 75-89, in F.O. Schmitt and F.G. Worden (Eds-in-Chief), *The Neurosciences: Third Study Program*. Cambridge (MA): MIT Press.
- Mindel, E.D., and M. Vernon (1971) *They Grow in Silence: The Deaf Child and His Family*. Silver Spring (MD): National Association of the Deaf.
- Montessori, M. (1967a) *The Absorbent Mind*. New York: Delta.
- (1967b) *The Discovery of the Child*. New York: Ballantine.
- (1983) *The Secret of Childhood*. London: Sangam Books.
- Moore, D.F., and C. Sweet (1990) Factors predictive of school achievement. Chapter 7, pp. 154-201, in D.F. Moore and K.P. Meadow-Orlans (Eds.), *Educational and Developmental Aspects of Deafness*. Washington, D.C.: Gallaudet University Press.
- Morris, R.L. (1989) Parapsychology. Chapter 11, pp. 232-256, in A.M. Colman and J.G. Beaumont (Eds.), *Psychology Survey 7*. Leicester: British Psychological Society and Routledge.
- Moskowitz, J.A. (1973) The sorcerer's apprentice, or the use of magic in child psychotherapy. *International Journal of Child Psychotherapy* **2**: 138-162.
- Myklebust, H.R. (1964) *The Psychology of Deafness: Sensory*

- Deprivation, Learning, and Adjustment (Second Edition). New York: Grune and Stratton.
- (1965) Development and Disorders of Written Language. Volume I: Picture Story Language Test. New York: Grune and Stratton.
- Naidoo, S. (1961) An Investigation Into Some Aspects of Ambiguous Handedness. M.A. Thesis, University of London.
- Nelson, K. (and others) (1986) Event Knowledge: Structure and Function in Development. Hillsdale (NJ): Lawrence Erlbaum Associates.
- Nicholas, S.M. (1976) [Untitled] Chapter 4, pp. 22-29, in P. Henderson (Ed.), Methods of Communication Currently Used in the Education of Deaf Children (Seminar Papers). London: Royal National Institute for the Deaf.
- Nideffer, R.M. (1985) Athletes' Guide to Mental Training. Champaign (IL): Human Kinetics.
- Nottebohm, F. (1970) Ontogeny of bird song. Science **167**: 950-956 (13 February).
- (1980) A continuum of sexes bedevils the search for sexual differences? Behavioral and Brain Sciences **3**(2): 245-246 (June).
- O'Connor, N., and B.M. Hermelin (1973) The spatial or temporal organization of short-term memory. Quarterly Journal of Experimental Psychology **25**(3): 335-343 (August).
- (1976) Backward and forward recall by deaf and hearing children. Quarterly Journal of Experimental Psychology **28**(1): 83-92 (February).
- O'Leary, D.S. (1980) A developmental study of interhemispheric transfer in children aged five to ten. Child Development **51**: 743-750.
- Oléron, P. (1964) Les Activités Intellectuelles. Paris: Presses Universitaires de France.
- Orton, S.T. (1937) Reading, Writing and Speech Problems in Children: A Presentation of Certain Types of Disorders in the Development of the Language Faculty. London: Chapman and Hall.
- Paulos, J.A. (1988) Innumeracy: Mathematical Illiteracy and Its Consequences. New York: Hill and Wang.
- Pease, A. (1981) Body Language: How to Read Others' Thoughts by Their Gestures. London: Sheldon Press.
- Petrinovich, L. (1973) Darwin and the representative

- expression of reality. Chapter 5, pp. 223-256, in P. Ekman (Ed.), *Darwin and Facial Expression: A Century of Research in Review*. New York: Academic Press.
- Phillips, E.M., and D.S. Pugh (1987) *How to Get a PhD: Managing the Peaks and Troughs of Research*. Milton Keynes: Open University.
- Phippard, D. (1977) Hemifield differences in visual perception in deaf and hearing subjects. *Neuropsychologia* **15**: 555-561.
- Piaget, J. (1959) *The Language and Thought of the Child* (Third Edition). London: Routledge and Kegan Paul.
- Poizner, H. (1983) Perception of movement in American Sign Language: Effects of linguistic structure and linguistic experience. *Perception and Psychophysics* **33**(3): 215-231.
- , E.S. Klima, and U. Bellugi (1987) *What the Hands Reveal about the Brain*. Cambridge (MA): MIT Press.
- Porac, C., and S. Coren (1981) *Lateral Preferences and Human Behavior*. New York: Springer-Verlag.
- Quigley, S.P., and P.V. Paul (1984) *Language and Deafness*. San Diego: College-Hill Press.
- Ramsay, D.S. (1980) Beginnings of bimanual handedness and speech in infants. *Infant Behavior and Development* **3**: 67-77.
- and S.L. Weber (1986) Infants' hand preference in a task involving complementary roles for the two hands. *Child Development* **57**(2): 300-307.
- Robbins, C., and C. Robbins (1980) *Music for the Hearing-Impaired and Other Special Groups: A Resource Manual and Curriculum Guide*. [St Louis:] Magnamusic-Baton.
- Ross, P. (1983) Cerebral specialization in deaf individuals. Chapter 13, pp. 287-313, in S.J. Segalowitz (Ed.), *Language Functions and Brain Organization*. New York: Academic Press.
- Sacks, O. (1990) *Seeing Voices: A Journey Into the World of the Deaf*. London: Picador/Pan Books.
- Schein, J.D. (1984) *Speaking the Language of Sign: The Art and Science of Signing*. New York: Doubleday.
- Schlesinger, H.S. (1985) The psychology of hearing loss. Chapter 7, pp. 99-118, in H. Orlans (Ed.), *Adjustment to Adult Hearing Loss* (Ed). San Diego: College-Hill Press.

- Schlesinger, I.M., and L. Namir (1978) Introduction. In I.M. Schlesinger and L. Namir (Eds), *Sign Language of the Deaf: Psychological, Linguistic, and Sociological Perspectives*. New York: Academic Press.
- Shakespeare, W. (1970) [The] *Winter's Tale*. London: Cornmarket Press. [From the 1856 publication by Charles Kean.]
- Sharron, H. (1987a) *Changing Children's Minds -- Reubin Feuerstein's Revolution in the Teaching of Intelligence*. London: Souvenir Press.
- (1987b) Teaching intelligence. *Special Children* 11: 22-25 (May).
- Simonton, O.C., S. Matthews-Simonton, and J.L. Creighton (1978) *Getting Well Again: A Step-by-Step, Self-Help Guide to Overcoming Cancer for Patients and Their Families*. Toronto: Bantam Books.
- Sorell, W. (1968) *The Story of the Human Hand*. London: Weidenfeld and Nicolson.
- Sperry, R.W. (1990) Forebrain commissurotomy and conscious awareness. Chapter 22, pp. 371-388, in C. Trevarthen (Ed.), *Brain Circuits and Functions of the Mind: Essays in Honor of Roger W. Sperry*. Cambridge: Cambridge University Press.
- Springer, S.P., and G. Deutsch (1985) *Left Brain, Right Brain* (Revised Edition). New York: W.H. Freeman.
- Studdert-Kennedy, M., and U. Bellugi (1980) Introduction. Pp. 3-12, in U. Bellugi and M. Studdert-Kennedy (Eds), *Signed and Spoken Language: Biological Constraints on Linguistic Form*. Dahlem Konferenzen. Berlin (March). Weinheim: Verlag Chemie.
- "
Sugarman, S. (1987) Young children's spontaneous inspection of negative instances in a search task. *Journal of Experimental Child Psychology* 44(2): 170-191 (October).
- Teit, J.A. (1978) Sign language of the Salishan tribes of the Western plateaus. In D.J. Umiker-Sebeok and T.A. Sebeok (Eds), *Aboriginal Sign Languages of the Americas and Australia, Volume 2* (pp. 77-90). New York: Plenum Press.
- Tervoort, B.T. (1978) Bilingual interference. Chapter 5, pp. 169-240, in I.M. Schlesinger and L. Namir (Eds), *Sign Language of the Deaf: Psychological, Linguistic, and Sociological Perspectives*. New York: Academic Press.
- Thatcher, R.W., R. McAlaster, M.L. Lester, R.L. Horst, and

- D.S. Cantor (1983) Hemispheric EEG asymmetries related to cognitive functioning in children. Chapter 7, pp. 125-146, in E. Perecman (Ed.), *Cognitive Processing in the Right Hemisphere*. New York: Academic Press.
- Tomlinson-Keasey, C., and R.R. Kelly (1978) The deaf child's symbolic world. *American Annals of the Deaf* **123**(4): 452-459 (June).
- Trevarthen, C. (1984) Hemispheric specialization. Chapter 25, pp. 1129-1190, in I. Darian-Smith (Section Ed.), *Handbook of Physiology -- The Nervous System III*. Washington, D.C.: American Physiological Society.
- UKRA (1991) Abstracts, 7th European Conference on Reading and 28th UK Reading Association Annual Course and Conference, Edinburgh, 29 July - 1 August.
- Vitale, B.M. (1982) *Unicorns Are Real: A Right-Brained Approach to Learning*. Rolling Hills Estates (CA): Jalmar Press.
- Waldron, M., K. Farber, and S. Rose (1984) EEG Alpha and Beta activity in normal and deaf subjects. Paper presented at the 1984 AREA National Conference. New Orleans (April).
- Watson, J.D. (1968) *The Double Helix: A Personal Account of the Discovery of the Structure of DNA*. London: Weidenfeld and Nicolson.
- Webster, A. (1986) *Deafness, Development and Literacy*. London: Methuen.
- Wechsler, D. (1971) *Manual for the Wechsler Preschool and Primary Scale of Intelligence*. Windsor, Berks.: NFER Publishing Company.
- (1976) *WISC-R Manual: Wechsler Intelligence Scale for Children -- Revised (Anglicized version)*. Windsor (Berks.): NFER Publishing Co.
- Wells, C.G. (1990) *Right Brain Sex: Using Creative Visualization to Enhance Sexual Pleasure*. Hemel Hempstead: Prentice Hall Press.
- Wheelwright (1959) *Heraclitus*. Princeton (NJ): Princeton University Press.
- Widdowson, H.G. (1975) *Stylistics and the Teaching of Literature*. London: Longman.
- Withrow, F.B. (1968) Immediate memory span of deaf and normally hearing children. *Exceptional Children* **35**(1): 33-41 (September).
- Wolff, A.B., and R.W. Thatcher (1990) Cortical reorganization in deaf children. *Journal of Clinical and*

Experimental Neuropsychology **12**(2): 209-221.

Wood, D. (1988) How Children Think and Learn. Oxford: Basil Blackwell.

-----, H. Wood, A. Griffiths, and I. Howarth (1986) Teaching and Talking with Deaf Children. Chichester: Wiley.

Young, R.M. (1978) Strategies and the structure of a cognitive skill. Chapter 11, pp. 357-401, in G. Underwood (Ed.): Strategies of Information Processing. London: Academic Press.

Zajonc, R.B. (1980) Feeling and thinking: Preferences need no inferences. American Psychologist **35**(2): 151-175 (February).

Zaporožhets, A.V. (1961) On the reflectory origin of visual perception of objects. Acta Psychologica **19**(1): 326-330.

----- (1965) The development of perception in the preschool child. Monographs of the Society for Research in Child Development **30**(2): 82-101.

APPENDIX A

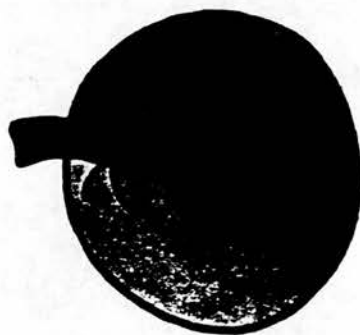
TASK MATERIALS

Preliminary Study and Main Study*

*[Additional sets of the Main Study are indicated within brackets]

TASK 1 [A]: PICTURE SEQUENCES

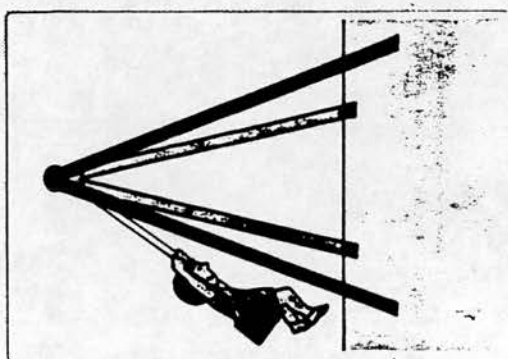
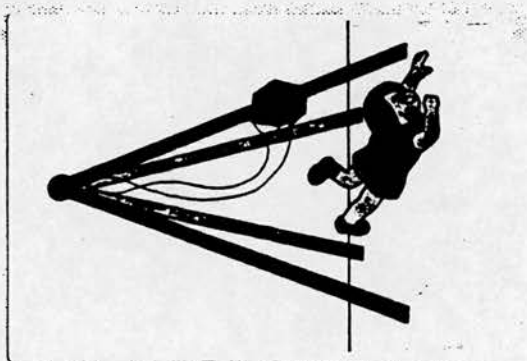
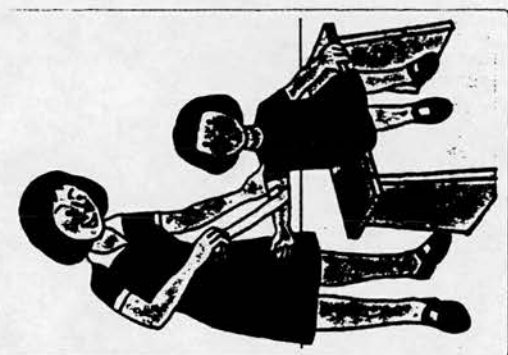
Actual size of each card:



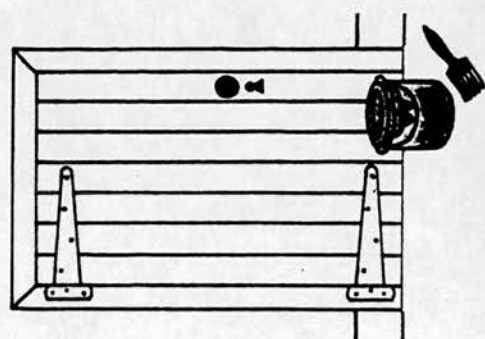
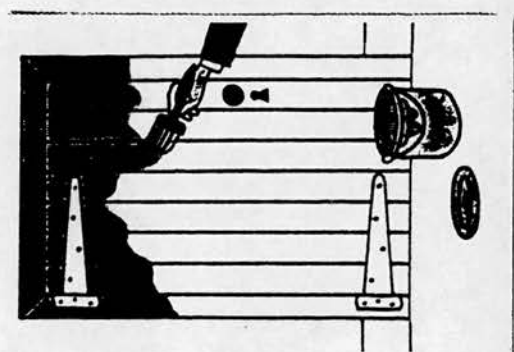
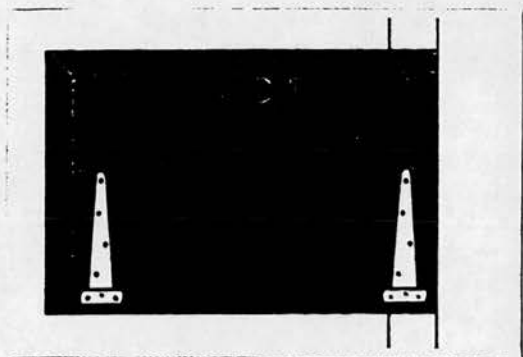
Demonstration set



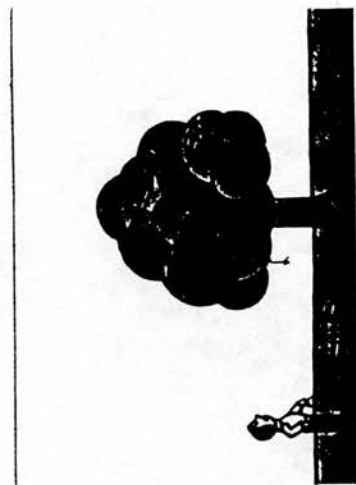
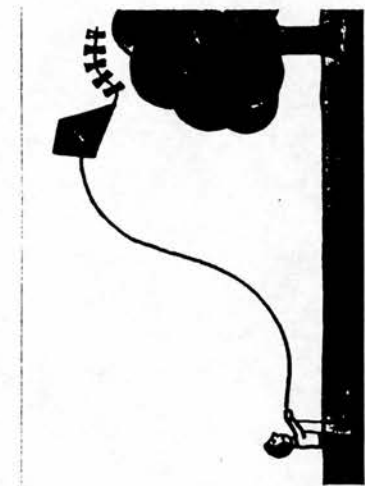
Test set 1



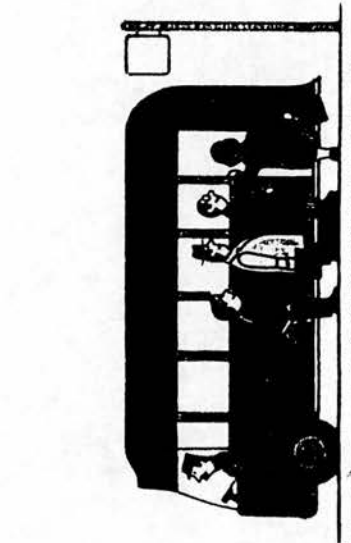
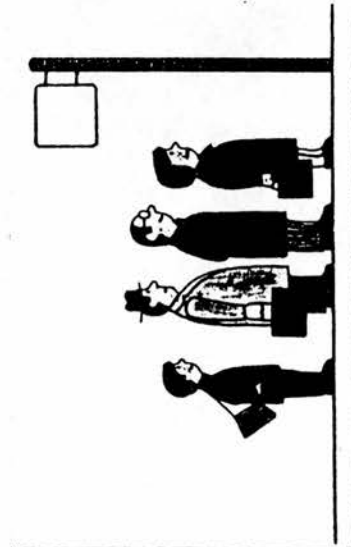
Test set 2



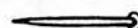
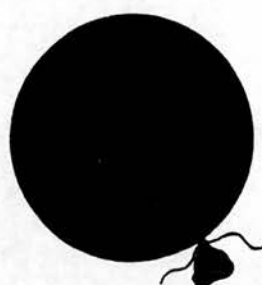
Test set 3



[Test set 4]



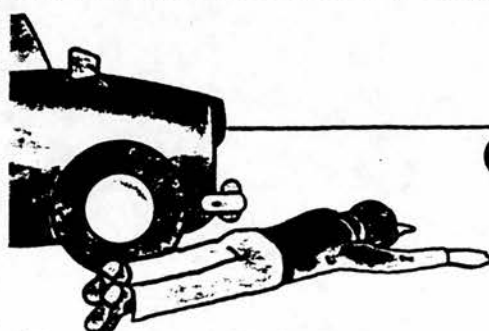
[Test set 5]



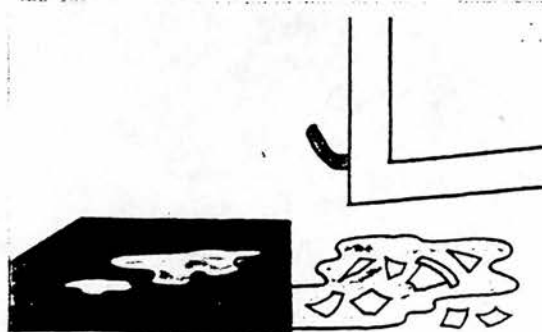
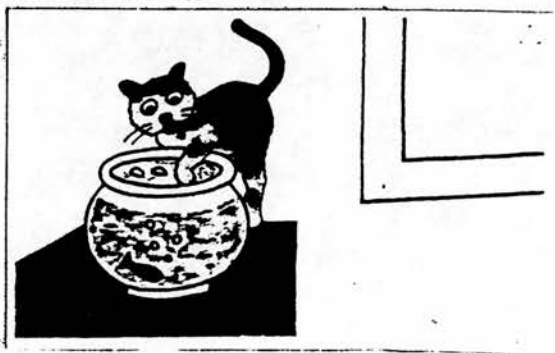
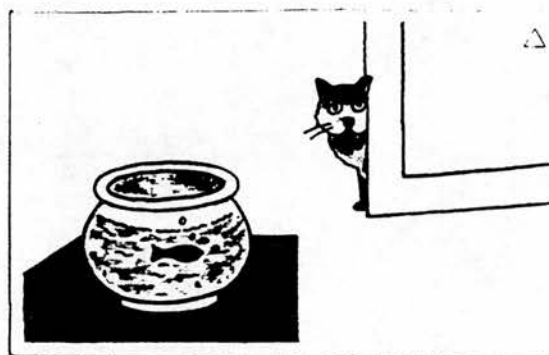
[Test set 6]



[Test set 7]



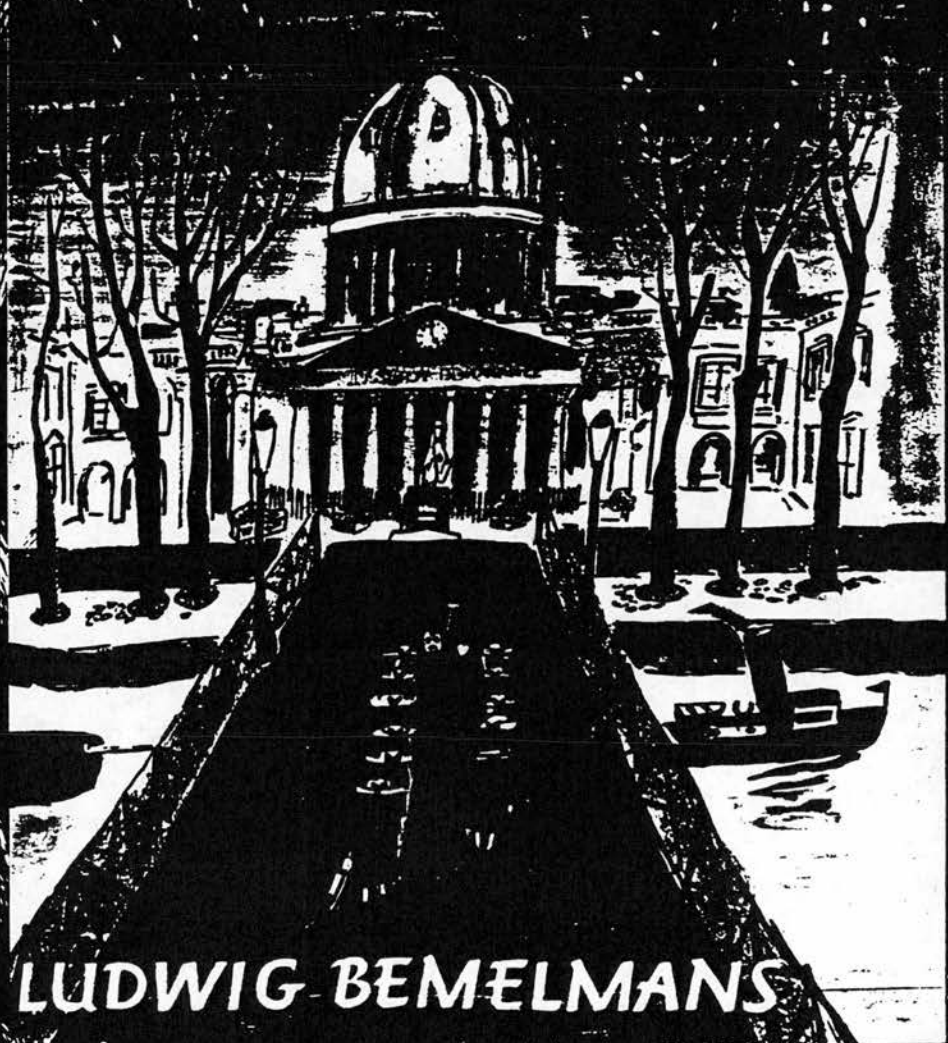
[Test set 8]



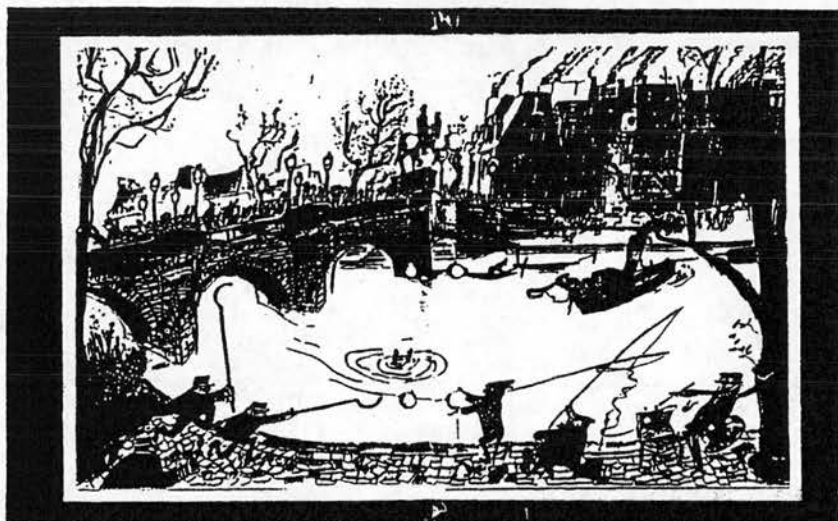
TASK 2: PICTURE STORY

Actual size of each page:

MADELINE'S RESCUE

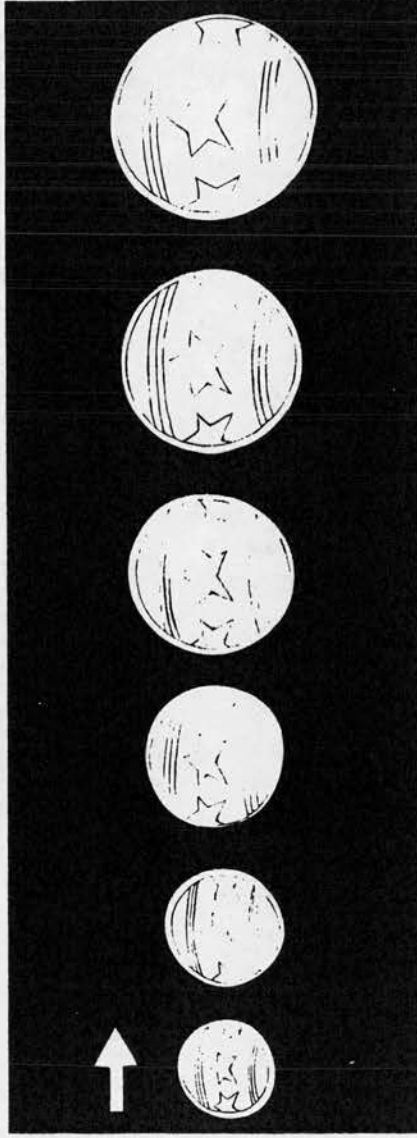


LUDWIG BEMELMANS

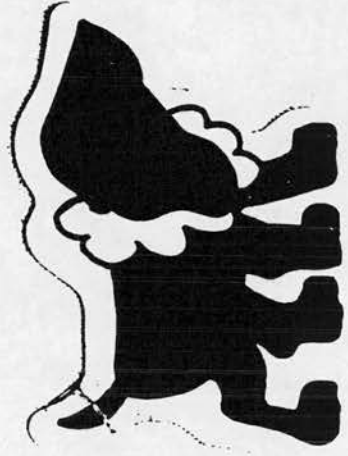
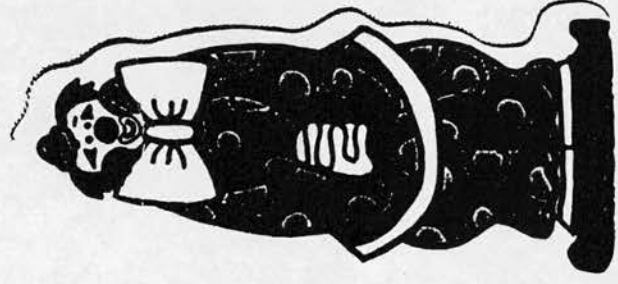


TASK 3 [B]: SIZE PROGRESSIONS

Demonstration set



Actual size of each smallest object:



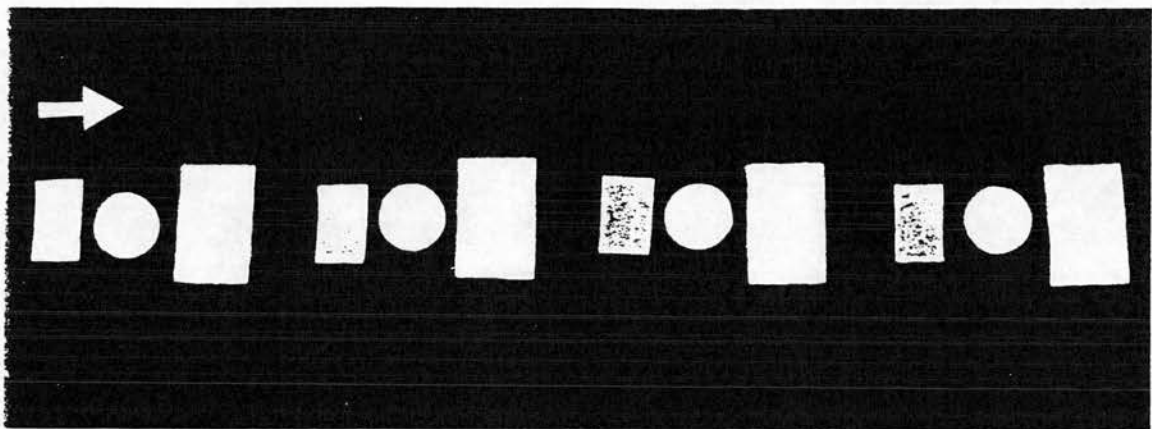
Test set 1



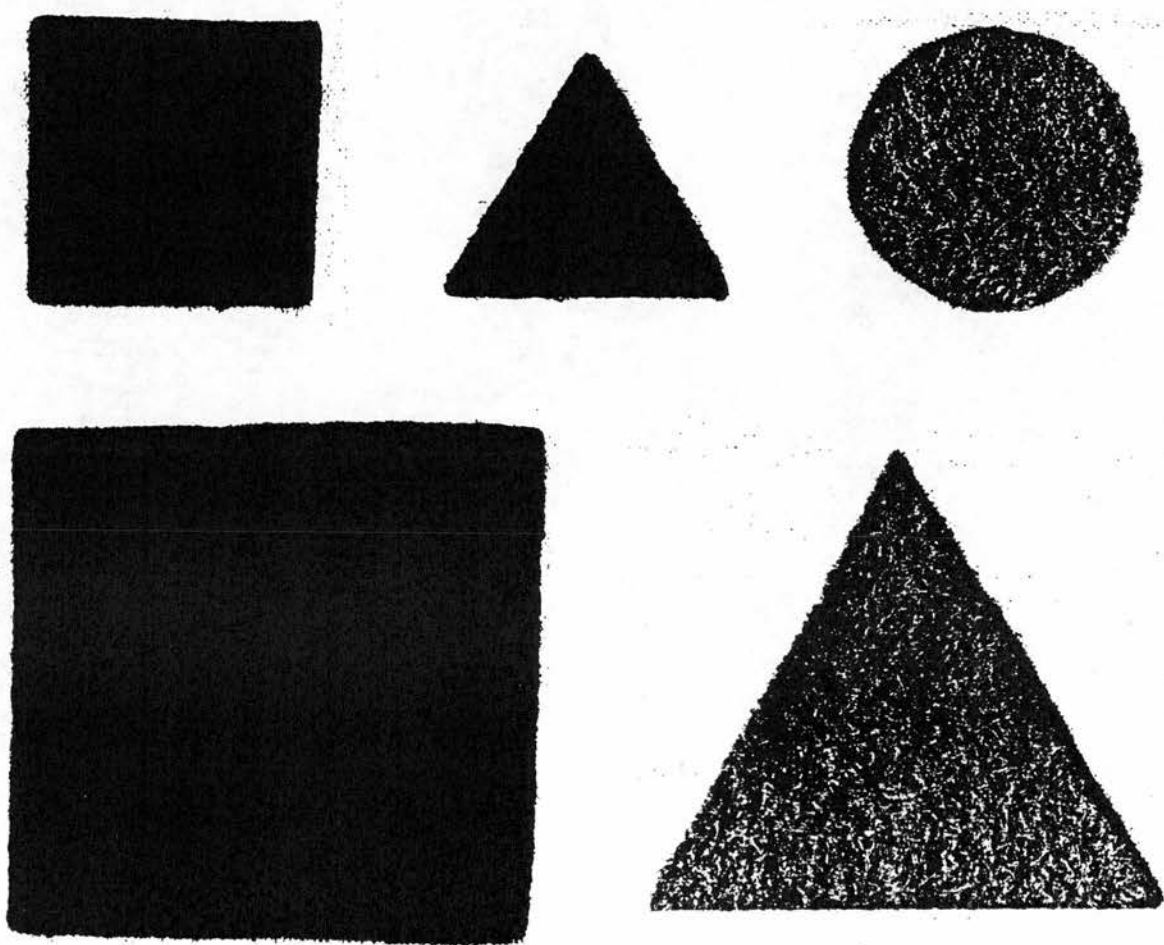
Test set 2



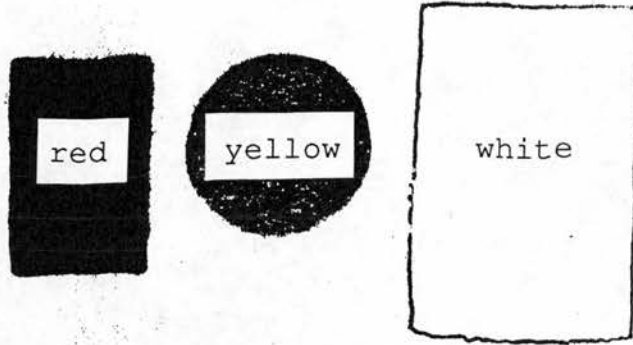
TASK 4 [C]: SHAPE PATTERN CONTINUATIONS



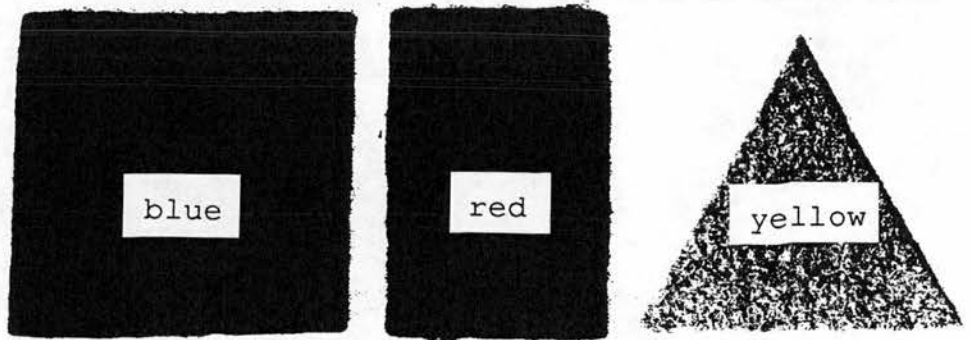
Samples of actual sizes of shapes:



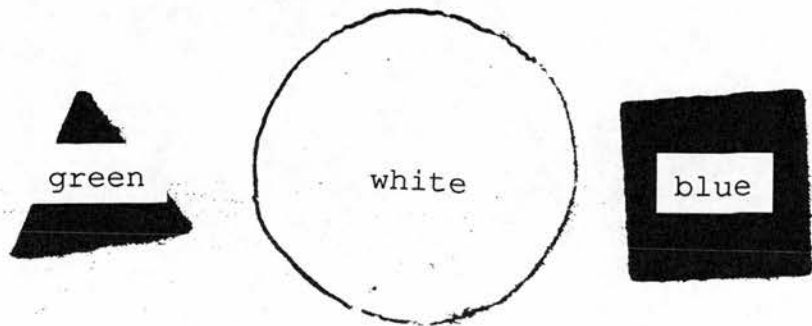
Demonstration set



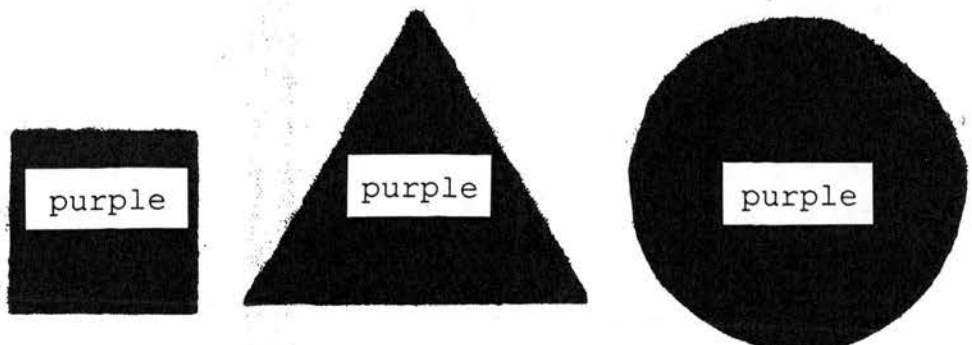
Test set 1



Test set 2



[Test set 3]



TASK 5: CLAPPING PATTERN IMITATIONS

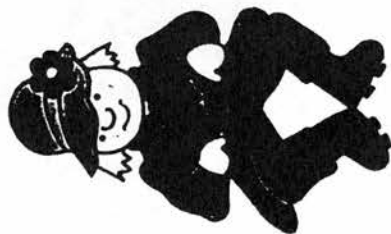
Demonstration set:	1	11	(clap, pause, clap, clap)
Test set 1:	11	1	(clap, clap, pause, clap)
Test set 2:	1	1	1 (quiet, loud, quiet)
Test set 3:	1	1	1 (quiet, quiet, loud)

TASK 6: MOVEMENT IMITATIONS

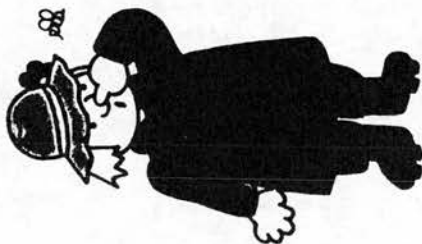
Actual size of each card:



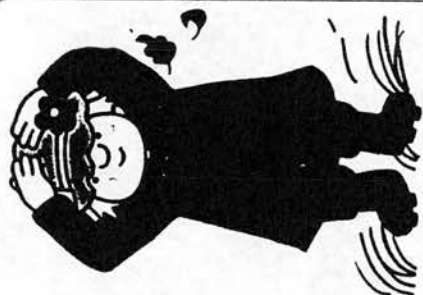
Simon Says cards: Demonstration set, two test sets,
and a conclusion set



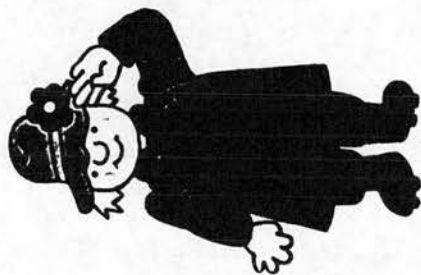
bend your knees



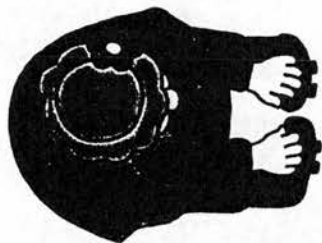
touch your nose



hands on your head



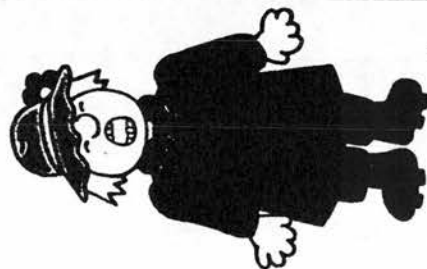
salute



touch your toes



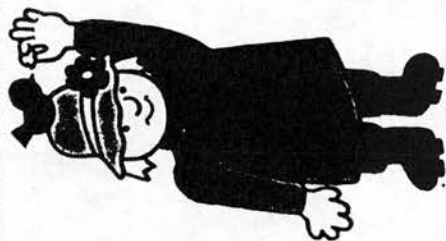
clap your hands



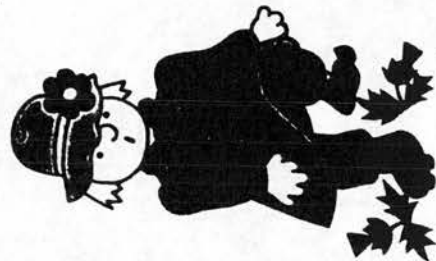
open your mouth



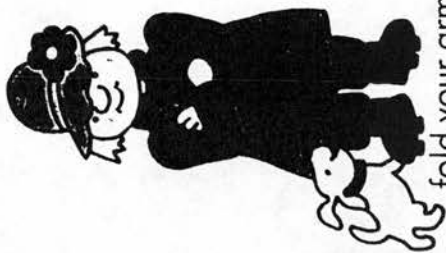
touch your ear



raise your arm



stand on one leg



fold your arms

APPENDIX B

DATA

1. TASK HANDEDNESS RATIOS
2. ERRORS IN TASKS A-C

B.1 DATA: TASK HANDEDNESS RATIOS

The children are listed in the order of highest to lowest total per cent score (the mean of the scores on Tasks A-C). The total scores and the age-adjusted scores (the ASDs) are shown in the furthest-right column. With tied scores, the first child listed was the youngest at the time of testing. The names of the **deaf children** appear in bold type; the names of the left-handed/ambidextrous children are in italics. Other notations are 'p' for Placements, 'A' for Assists, 'C' for Collections, and 'm' for mean.

Children		TASK A										TASK B				TASK C				TOTAL % SCORE [ASD]
		Handedness ratios/Sets										% Score		% Score		Sets		% Score		
		Sets : 1-6m :	1	2	3	4	5	6	7	8	1	2	1-2	1	2	3	1-3			
Joel	100	P -.133	-.333	.333	0	.200	-1	0	.600	100	P .200	.666	.433	100	P .800	.455	.333	.529	100	
		A -.232	-.286	-.176	-.250	-.011	-.333	-.375	0		A .067	.250	.159		A .600	.267	.103	.323	[+33]	
		C 0	0	0	0	0	0	0	.333		C 1	-.333	.334		C 1	-1	1	.333		
		PCm -.067	-.167	.167	0	.100	-.500	0	.467		PCm .600	.167	.384		PCm .900	-.273	.667	.431		
Polly	100	P .400	-.200	.500	.500	.200	0	1	1	100	P -.429	0	-.215	100	P 1	.800	1	.933	100	
		A .064	.059	.059	-.111	.053	.231	.143	.172		A -.238	0	-.119		A .067	.182	.172	.140	[+24]	
		C .778	.333	.333	1	1	1	1	-.714		C -.500	-1	-.750		C -1	-1	-1	-1		
		PCm .589	.267	.750	.417	.600	.500	1	.143		PCm -.465	-.500	-.483		PCm 0	-.100	0	-.033		
Alice	100	P .611	.333	1	1	.333	0	1	.500	100	P .250	.667	.459	100	P .556	.800	1	.785	100	
		A .150	.200	.273	.143	.143	0	.143	.231	.500	A -.053	.231	.089		A .125	-.077	.100	.049	[-1]	
		C -.083	-1	-1	.500	-1	1	1	1	1	C .667	1	.834		C -1	1	1	.333		
		PCm .264	-.334	0	.750	-.334	.500	1	.750	1	PCm .459	.834	.647		PCm -.222	.900	1	.559		
Tessa	90	P .056	.333	-.333	-.333	-.333	1	0	.500	-.200	100	P .333	0	.167	100	P .556	-.200	-.400	96.7	
		A .314	-.333	-.529	-.250	0	-.273	-.500	-.222	-.071	A -.120	-.304	-.212		A .059	-.125	-.250	-.105	[+24]	
		C -.778	-1	-1	-1	.333	-1	-1	-1	-1	C -1	-1	-1		C -1	-1	-1	-1		
		PCm -.361	-.334	-.667	0	0	0	-.500	-.250	-.600	PCm -.334	-.500	-.417		PCm -.222	-.600	-.700	-.508		
Liam	100	P -.472	.333	.333	-.500	-1	-1	-1	0	.600	83	P -.143	-.333	-.238	100	P .333	.333	1	94.3	
		A .136	-.091	-.167	-.250	-.059	0	-.250	-.077	-.133	A -.200	.177	-.012		A 0	.217	.048	.088	[+11]	
		C -.639	-1	-.333	-1	-.500	-1	0	-.500	-.667	C -1	1	0		C -.333	1	1	.556		
		PCm -.556	-.334	0	-.750	-.750	-.500	-.500	-.250	-.034	PCm -.572	.334	-.119		PCm 0	.667	1	.556		
Megan	90	P .567	-.600	1	1	1	0	1	.667	.667	92	P 1	1	1	100	P .800	.833	1	94	
		A -.045	-.368	-.263	.053	.143	-.067	.231	-.071	.086	A -.091	.176	.043		A .238	-.179	-.226	-.056	[+11]	
		C .167	.333	.333	0	.333	0	0	.333	1	C -.429	-.714	-.572		C -.143	.273	.286	.139		
		PCm .367	-.134	.667	.500	.667	0	.500	.500	.834	PCm .286	.143	.214		PCm .329	.553	.643	.508		
Max	80	P .317	-.500	1	1	-.600	0	1	0	.231	100	P .429	.667	.548	89	P .636	.857	.777	89.7	
		A .154	-.120	-.250	-.400	-.368	.091	.125	-.091	-.158	A -.070	-.509	-.290		A -.227	-.551	-.070	-.283	[+13]	
		C -.056	-.333	.333	-.333	0	0	0	0	0	C 0	1	.500		C 0	.111	.333	.148		
		PCm .131	-.417	.667	.334	-.300	0	.500	0	.116	PCm .215	.834	.525		PCm .318	.484	.555	.452		

Children	% Score	TASK A										TASK B				TASK C				TOTAL % SCORE [ASD]	
		Handedness ratios/Sets										% Score	Sets		% Score	Sets					
		Sets : 1-6m :	1	2	3	4	5	6	7	8	1		2	1-2		1	2	3	1-3		
Richard	70	P .456 :	.600	1	.800	.333	0	0	1	1	1	92	P .667	.750	1	100	P 1	.833	1	.944	87.3
		A .088 :	.111	.500	.037	.077	-.200	0	.273	.333	.333		A -.125	.517	-.375		A .222	.313	0	.178	[+6]
		C .111 :	0	.333	.333	0	0	0	.500	-.333	-.333		C 1	.778	0		C .833	1	1	.945	
Nathan	90	PCm .284 :	.300	.667	.567	.167	0	0	.750	.334	.334	100	PCm .834	.764	0		PCm .917	.917	1	.945	
		P .611 :	.333	1	.333	1	0	1	1	.200	.200	100	P .667	1	1	67	P .778	1	.333	.704	85.7
		A -.078 :	-.077	-.375	-.200	.091	0	.091	.200	.226	.226		A -.364	-.375	-.370		A .143	.500	.111	.251	[0]
Gregory	100	C .056 :	0	0	.333	0	0	0	-.333	1	1		C .091	0	0		C -.333	1	1	-.778	
		PCm .333 :	.167	.5	.333	.500	0	.5	.334	-.400	-.400		PCm .379	.500	.440		PCm .223	0	-.334	-.037	
		P 0 :	-.333	.333	.333	-.333	0	0	.500	.143	.143	100	P .667	.333	.333	56	P .800	.600	1	.800	85.3
Rebecca	50	A .063 :	0	-.091	.429	-.059	.600	-.500	-.500	.222	.222	100	P .667	.333	.333		P .250	.444	.182	.292	[+1]
		C .756 :	.333	1	1	.200	1	1	1	1	1		C .250	1	.625		C 1	1	.167	.722	
		PCm .378 :	0	.667	.667	-.067	.500	.500	.750	.572	.572		PCm .459	.667	.563		PCm .900	.800	.584	.761	
Jasper	100	P .600 :	.600	1	1	1	0	0	.667	.714	.714	100	P 1	.333	.333	100	P .778	0	.556	.445	83.3
		A .066 :	.217	.111	0	-.077	.143	0	-.238	.040	.040		A .300	.091	.196		A -.310	-.324	.133	-.167	[+10]
		C .028 :	.333	-.333	-.500	.333	0	.333	1	.600	.600		C -1	1	0		C -1	.200	-.200	-.333	
Lesley	40	PCm .314 :	.467	.334	.250	.667	0	.167	.834	.657	.657		PCm 0	.667	.334		PCm -.111	.1	.178	.056	
		P .556 :	1	1	1	.333	0	0	1	.429	.429	92	P .333	.333	.333	56	P 1	1	1	1	82.7
		A .168 :	.059	.556	.467	-.273	0	.200	-.200	-.217	-.217		A .071	.176	.124		A .273	.259	.333	.288	[+15]
Moir	50	C .036 :	.333	0	0	0	0	0	.333	-.200	-.200		C .333	0	.167		C 1	-.250	.143	.298	
		PCm .306 :	.667	.500	.500	.167	0	0	.667	.115	.115		PCm .333	.167	.250		PCm 1	.375	.572	.649	
		P -.222 :	-.500	-.500	-.333	.333	0	-.333	0	0	0	100	P -.714	0	-.357	100	P .200	-.111	0	.030	80
Elspeth	30	A .110 :	-.200	-.250	-.231	.130	-.111	0	.034	-.186	-.186		A -.258	-.100	-.179		A .161	.064	.231	.152	[+16.5]
		C -.278 :	0	0	-.333	0	-.333	1	-.500	-.600	-.600		C -.714	-.500	-.607		C 0	-.294	-.203	-.431	
		PCm .250 :	-.250	-.250	-.333	.167	-.167	-.667	-.250	-.300	-.300		PCm -.714	-.250	-.482		PCm .100	-.203	-.500	-.201	
Gayle	50	P .778 :	-.333	1	1	1	1	1	.500	.600	.600	92	P .500	1	.750	89	P 1	.667	.818	.828	77
		A -.047 :	-.625	.167	.176	0	.111	-.111	-.067	.300	.300		A .286	.235	.261		A .385	.130	.571	.362	[+26]
		C -.833 :	-1	-1	-1	-1	0	0	1	-1	-1		C -.053	1	.474		C 1	1	1	1	
Ernest	40	PCm .028 :	-.667	0	0	0	0	.500	-.250	-.200	-.200		PCm .224	1	.612		PCm 1	.834	.909	.914	
		P .369 :	.429	.429	.429	.429	0	.500	1	.600	.600	100	P .667	1	.834		P 1	.800	1	.933	76.7
		A -.110 :	-.217	-.040	-.130	0	-.273	0	-.217	-.172	-.172		A -.053	0	-.027		A .030	.161	0	.064	[-2.5]
Daniel	30	C .667 :	.333	.333	.333	1	1	1	-.600	.200	.200		C .333	-.429	-.048		C -.667	-.692	-1	-.074	
		PCm .518 :	.381	.048	.715	.715	.500	.750	.200	.400	.400		PCm .500	.286	.393		PCm .170	.054	0	.074	
		P .104 :	.143	.333	0	-.250	.200	.200	-.111	-.167	-.167	92	P .250	.714	.482	89	P 1	.867	.556	.808	70.3
Ernest	40	A -.130 :	-.250	-.333	-.100	-.222	.067	.059	0	-.357	-.357		A 0	.167	.084		A .143	.150	0	.098	[-12]
		C .378 :	1	.600	.333	.333	0	0	1	1	1		C 1	1	1		C 1	.263	1	.754	
		PCm .241 :	.572	.467	.167	.042	.100	.100	.445	.417	.417		PCm .625	.857	.741		PCm 1	.565	.778	.781	
Daniel	40	P .750 :	1	1	1	1	1	1	1	.500	.333	92	P .385	-.333	.026	78	P .800	.714	.666	.727	70
		A -.095 :	0	-.111	-.167	-.200	0	-.091	0	-.282	-.282		A .056	-.161	-.053		A -.071	.029	.073	.010	[+18]
		C .500 :	.333	.333	.333	1	0	1	1	1	1		C 0	1	.500		C 0	-.333	-.500	-.278	
Daniel	20	PCm .625 :	.667	.667	1	-.084	.500	1	.250	0	0		PCm .193	.334	.264		PCm .400	.191	.083	.225	
		P .672 :	1	.500	1	1	.200	.333	1	.800	.800	100	P .818	1	.909	89	P 1	.692	.600	.764	69.7
		A .433 :	.714	0	0	1	.333	.667	.385	.053	.053		A .167	.556	.362		A .222	0	.333	.185	[-13]
Daniel	20	C .056 :	0	-.333	.333	0	0	0	.333	.200	.200		C .667	0	.334		C -.250	-1	-.714	-.655	
		PCm .364 :	.500	.084	.667	.667	.100	.167	.667	.500	.500		PCm .743	.500	.622		PCm .375	-.154	-.057	.055	

Children	% Score	TASK A								TASK B				TASK C				TOTAL % SCORE [ASD]						
		Handedness ratios/Sets								% Score	Sets			% Score	Sets									
		1-6m :	1	2	3	4	5	6	7		8	1	2		1-2	3	1-3							
Joan	30	P	.489 :	.600	.333	1	1	0	0	0	.111		P	1	.667	:	.834		P	1	.600	:	.600	
		A	-.028 :	0		-.077	0	-.200		A	-.128	-.161	:	-.145		A	-.097		C	-.097	.111	:	-.250	
		C	-.445 :	-1	1	.333	-1	-1		C	.333	.667	:	.500		C	.818		P	.618	.757	:	.757	
		PCm	.022 :	-.200	.667	.667	0	-.500	-.500		PCm	.667	.667	:	.667		PCm	.909			.509	.679	:	.679
Duncan	50	P	.022 :	-.200	0	.333	.333	0	-.333	-1	.200		P	-.455	-.500	:	-.478		P	.143	.250	:	.333	
		A	-.234 :	-.273	-.400	-.333	-.125	0	-.273	-.310	-.467		A	-.091	-.250	:	-.171		A	-.071	.100	:	.053	
		C	0 :	0	0	0	0	0	0	-.500	0		C	-.333	0	:	-.167		C	0	-.231	:	-1	
		PCm	.011 :	-.100	0	.167	.167	0	-.167	-.750	.100		PCm	-.394	-.250	:	-.322		PCm	.072	.010	:	-.334	
Bruce	40	P	.326 :	.429	.429	.667	.429	0	0	.333	.400		P	.333	1	:	.667		P	.556	1	:	.714	
		A	.092 :	.111	.185	.059	.048	.059	.091	-.143	.037		A	0	.067	:	.034		A	-.217	.529	:	.385	
		C	-.222 :	-.333	0	-1	0	0	0	0	0		C	-.167	-1	:	-.584		C	1	0	:	.667	
		PCm	.052 :	.048	.215	-.167	.215	0	0	.167	.200		PCm	.083	0	:	.042		PCm	.778	.500	:	.691	
Mhairi	40	P	.611 :	1	1	-.333	1	0	1	.500		P	1	.333	:	.667		P	1	1	:	1		
		A	.238 :	0	.429	.154	.400	.111	.333	.333		A	-.071	-.133	:	-.102		A	.478	.400	:	-.040		
		C	0 :	1	-1	.333	-.333	-1	1	-1	-.833		C	1	.667	:	.834		C	.375	.375	:	-.083	
		PCm	.306 :	1	0	0	.334	-.500	1	-.250	-.100		PCm	1	.500	:	.750		PCm	.688	.688	:	0	
William	50	P	-.194 :	-.500	-.333	0	0	-.333	0	0	0		P	-.590	-.250	:	-.420		P	-.556	-.333	:	-.556	
		A	.500 :	1	0	1	1	0	0	-1	-.833		A	-.178	-.400	:	-.289		A	-.331	-.467	:	-.625	
		C	.117 :	1	0	.500	0	.200	-1	-.143	-.200		C	-.667	-1	:	-.834		C	-1	-1	:	-1	
		PCm	-.039 :	.250	-.167	.250	0	-.067	-.500	-.072	-.100		PCm	-.629	-.625	:	-.627		PCm	-.778	-.667	:	-.778	
Samuel	40	P	-.424 :	-.600	-1	-.600	-.200	0	-.143	-.143	-.111		P	-.429	-.750	:	-.590		P	-.778	-.273	:	-.778	
		A	-.401 :	-.571	-.500	-.625	-.143	-.500	-.067	-.636	-.579		A	-.385	-.926	:	-.656		A	-.500	-.294	:	-.833	
		C	-.556 :	-1	-1	-1	0	-.333	0	-.200	-1		C	-.714	-1	:	-.857		C	-1	-1	:	-1	
		PCm	-.490 :	-.800	-1	-.800	-.100	-.167	-.072	-.172	-.556		PCm	-.572	-.875	:	-.724		PCm	-.889	-.637	:	-.889	
Ali	20	P	.115 :	.333	.067	.222	.067	0	0	0		P	1	1	:	1		P	1	.818	1	:	.939	
		A	.583 :	0	0	1	1	1	.500		A	.600	.778	:	.689		A	.100	.448	.353	:	.300		
		C	1 :	1	1	1	1	1	1	1		C	1	1	:	1		C	1	1	1	:	1	
		PCm	.558 :	.667	.534	.611	.534	.500	.500		PCm	1	1	:	1		PCm	1	.909	1	:	.970		
Jack	20	P	.272 :	.333	-.200	.333	.500	.333	.333	.200		P	.200	.750	:	.475		P	1	1	1	:	1	
		A	.016 :	-.067	-.083	.067	.100	.077	0	0	0		A	-.059	.286	:	.114		A	.043	0	:	.014	
		C	.583 :	.333	.333	.333	.500	1	1	1		C	.583	.333	:	.436		C	1	1	1	:	1	
		PCm	.428 :	.333	.067	.333	.500	.667	.667	.600		PCm	.369	.542	:	.456		PCm	1	1	1	:	1	
Imran	50	P	.006 :	.500	0	.200	.333	0	-1	-.200	-.200		P	.333	.250	:	.292		P	.556	.800	1	:	.785
		A	-.111 :	0	.385	.200	0	-.250	-1	-.538	0		A	0	-.238	:	-.119		A	-.053	.200	.190	:	.112
		C	.611 :	0	.333	1	.333	1	1	1	-.600		C	0	1	:	.500		C	-1	-.692	-1	:	-.897
		PCm	.308 :	.250	.167	.600	.333	.500	0	.400	-.400		PCm	.167	.625	:	.396		PCm	-.222	.054	0	:	-.056
Rhona	30	P	.333 :	.333	-.333	.333	.333	1	.333			P	.429	.714	:	.572		P	.800	.600	.846	:	.749	
		A	-.064 :	-.200	-.412	0	-.250	.333	.143	.125		A	.250	0	:	.125		A	.176	.149	.333	:	.219	
		C	.361 :	.500	.500	.333	.500	1	.333	.667		C	.333	1	:	.667		C	.167	.500	-.167	:	.167	
		PCm	.347 :	.417	-.417	.333	.417	1	.333	.619		PCm	.381	.857	:	.619		PCm	.484	.550	.340	:	.458	
Miranda	40	P	.242 :	.500	.667	.143	.143	0	0	.757		P	.800	.714	:	.757		P	.778	1	.778	:	.852	
		A	.219 :	.032	.333	.176	.111	.231	.429	.375		A	.333	.417	:	.375		A	.300	.407	.176	:	.294	
		C	.889 :	1	1	1	.333	1	1	.077		C	1	.077	:	.539		C	1	1	1	:	1	
		PCm	.566 :	.750	.834	.572	.238	.500	.500	.648		PCm	.900	.396	:	.648		PCm	.889	1	.889	:	.926	

Children	% Score	TASK A								TASK B				TASK C				TOTAL % SCORE [ASD]	
		Handedness ratios/Sets								% Score				Sets					
		1-6m	1	2	3	4	5	6	7	8	% Score	1	2	1-2	% Score	1	2		3	1-3
Martin	90	P .079 : .333	.143	-.333	.333	0	0	-.273	-.143	67	P 0	-.667	:-.334	11	P 0	.455	1	.485	56 [+26]
	A -.078 : -.176	.143	.053	-.375	-.111	0	0	-.030	0	A -.030	0	0	:-.015	A -.200	.103	-.190	:-.096		
	C -.639 : -.1	-.500	-.1	-.333	0	-1	0	-.636	-.667	C -.636	.333	.333	:-.152	C -.333	-.067	-.571	:-.324		
	PCm -.280 : -.334	-.179	-.667	0	0	0	-.500	-.387	-.405	PCm -.318	-.167	-.167	:-.243	PCm -.167	.194	.215	:-.081		
Kathryn	40	P 1 : 1	1	1	1	1	1	0	0	58	P .429	.429	:-.429	67	P 1	1	.778	.926	55 [+18]
	A .257 : .375	.333	-.333	.500	.333	.333	.333	.333	.333	A .667	.429	.429	:-.548	A -.217	.273	.520	:-.192		
	C .556 : 1	1	.333	1	1	1	-1	.333	0	C -.714	-1	-1	:-.857	C .500	-.714	-1	:-.405		
	PCm .778 : 1	1	.667	1	1	1	0	0	0	PCm -.143	-.286	-.286	:-.214	PCm .750	.143	-.111	:-.261		
Malcolm	30	P .222 : 1	-.333	.333	.333	0	0	0	0	33	P .375	1	:-.688	100	P .556	0	.385	.314	54.3 [+1]
	A .162 : -.333	1	0	.571	.500	.231	0	.392	0	A .200	.583	.583	:-.392	A -.143	0	.019	:-.041		
	C 1 : 1	1	1	1	1	1	1	-.215	0	C -.429	0	0	:-.215	C -.067	-.091	0	:-.053		
	PCm .611 : 1	.334	.667	.667	.667	.500	.500	.237	0	PCm -.027	.500	.500	:-.237	PCm .244	-.046	.193	:-.130		
Linda	20	P .500 : -.333	.333	1	1	1	0	.500	.600	92	P .429	1	:-.715	44	P .750	.600	.778	.709	52 [-20.5]
	A -.125 : -.273	-.231	-.238	-.100	-.273	.091	0	-.034	-.034	A 0	.158	.158	:-.079	A .143	.130	.167	:-.147		
	C .139 : 1	.500	-.333	-.333	-.333	0	0	1	1	C .429	1	1	:-.715	C 1	1	1	:-.053		
	PCm .320 : .334	.417	.334	.334	.334	.500	0	.750	.800	PCm .429	1	1	:-.715	PCm .875	.800	.889	:-.855		
Murdo	50	P -.111 : -.333	.333	0	.333	-.1	0	.500	.375	25	P -.130	-.048	:-.089	78	P .385	.500	.143	.343	51 [-16]
	A .155 : -.091	-.154	-.333	-.294	-.294	-.333	.273	0	.077	A -.172	-.135	-.135	:-.154	A -.063	-.032	-.133	:-.076		
	C .056 : -.333	0	0	0	0	0	0	-.500	-.200	C 1	.600	.600	:-.200	C .500	-.333	.455	:-.126		
	PCm -.083 : -.333	0	.167	.167	.167	-.500	0	0	.088	PCm .435	-.324	-.324	:-.056	PCm -.058	.084	.299	:-.108		
Suzannah	30	P .889 : 1	.333	1	1	1	1	-.143	.556	33	P 1	.667	:-.834	89	P 1	.833	1	.944	50.7 [+8]
	A .353 : .667	.579	.455	.867	-.250	-.200	-.200	-.158	-.238	A .143	0	0	:-.072	A 0	-.087	.172	:-.028		
	C .889 : 1	1	1	.333	.333	1	1	1	1	C 0	.500	.500	:-.250	C -.176	-.077	.333	:-.027		
	PCm .889 : 1	.667	1	.667	.667	1	1	.429	.778	PCm .500	.584	.584	:-.542	PCm .412	.378	.667	:-.486		
Claudia	50	P -.111 : 0	.333	.333	0	-.1	-.333	-.143	.556	100	P .273	.091	:-.182	0	P 1	.500	.667	.722	50 [-13]
	A -.041 : 0	0	-.391	0	.143	0	0	.257	-.111	A 0	.333	.333	:-.167	A .200	.067	0	:-.089		
	C .222 : 1	-.333	.333	.333	.333	0	0	0	.200	C .500	1	1	:-.750	C .091	1	.636	:-.576		
	PCm .056 : .500	.500	.333	.167	.167	-.500	-.167	-.072	.378	PCm .387	.546	.546	:-.467	PCm .546	.750	.652	:-.649		
Colin	10	P .083 : .500	0	.333	-.333	0	0	0	0	58	P 1	1	:-.1	78	P 1	.692	.556	.749	48.7 [+1]
	A -.099 : -.500	-.238	0	.286	-.143	0	0	0	0	A -.059	.091	.091	:-.016	A 0	.097	.059	:-.052		
	C .056 : 0	0	-.333	0	0	0	0	0	0	C -.333	0	0	:-.167	C .818	.538	.667	:-.674		
	PCm .014 : .250	.250	0	-.167	0	0	0	.417	0	PCm .334	.500	.500	:-.417	PCm .909	.615	.612	:-.712		
Anthony	60	P .200 : .333	.333	.200	.333	0	0	0	0	58	P -.111	-.667	:-.389	22	P .385	.833	.800	.673	46.7 [+13]
	A .078 : .158	.154	.034	.070	.070	.053	0	.111	0	A -.077	-.935	-.935	:-.506	A .130	.200	.200	:-.177		
	C .444 : .333	.333	.333	1	.333	0	1	0	0	C -.143	.667	.667	:-.262	C -.167	.231	.167	:-.077		
	PCm .322 : .333	.167	.267	.667	.667	0	.500	0	.378	PCm -.127	0	0	:-.064	PCm .109	.532	.484	:-.375		
Abigail	40	P .722 : .333	.500	.500	1	1	1	.500	.200	100	P .200	1	:-.600	0	P 1	1	1	.46.7 [+11]	
	A .228 : -.130	.385	.231	.455	.455	0	.429	.188	.200	A 0	.200	.200	:-.100	A .231	.071	.429	:-.244		
	C .500 : 0	1	1	1	1	-1	1	0	-1	C .167	1	1	:-.584	C 1	.200	1	:-.733		
	PCm .611 : .167	.750	.750	1	1	0	1	.250	-.400	PCm .184	1	1	:-.592	PCm 1	.600	1	:-.867		
Beth	40	P .300 : 0	.200	1	.600	0	0	.500	.200	83	P .667	.667	:-.667	11	P 1	1	1	.44.7 [+18]	
	A -.009 : -.238	.100	.143	.143	.143	-.200	0	.188	.200	A .118	.375	.375	:-.247	A .692	.400	.444	:-.512		
	C 0 : -.333	-.333	.333	.333	.333	0	0	0	-1	C -.167	-1	-1	:-.584	C .167	-.455	-.500	:-.263		
	PCm .150 : -.167	-.067	.667	.467	.467	0	0	.250	-.400	PCm .250	-.167	-.167	:-.042	PCm .584	.273	.250	:-.369		

Children	% Score	TASK A								TASK B				TASK C				TOTAL % SCORE [ASD]		
		Sets : 1-6m :				Handedness ratios/Sets				% Score	Sets : 1-2 :		% Score	Sets : 1-3 :						
		1	2	3	4	5	6	7	8		1	2		3	4					
Heather	20	P	-0.194 :	-0.333	-0.333	0.500	0	0	0	92	P	1	0.714 :	0.857	22	P	1	1	1	44.7
		A	-0.212 :	-0.043	0.067	-0.286	-0.167	-0.429		A	0.304	0.077 :	0.191		A	0.238	0.263	0.405		
		C	0.056 :	-0.1	0.333	-0.1	0.500	0	0	C	0	1	0.500	0.500		C	0.600	0.571	0.557	
		PCm	-0.069 :	-0.334	0	-0.250	0.500	0		PCm	0.500	0.857 :	0.679		PCm	0.800	0.786	0.779		
Charles	50	P	0.084 :	-0.333	-0.334	0.500	-0.333	0	0	75	P	0.143	0.500 :	0.322	0	P	1	1	1	41.7
		A	-0.032 :	-0.167	-0.091	-0.077	0.143	-0.091	0.429	A	0.080	0.317 :	0.199		A	-0.375	0.391	0.116		
		C	0.444 :	0.333	1	0.333	0	0	0	C	1	1	0.500	0.661		C	0.091	1	0.697	
		PCm	0.264 :	0.333	0.334	0.417	-0.167	0	0.800	PCm	0.572	0.750 :	0.661		PCm	0.546	1	0.849		
Hamish	10	P	-0.333 :	-0.333	-0.333	-0.333	-0.333	0	0	58	P	1	1	0.556 :	0.550	56	P	0.600	0.800	41.3
		A	-0.050 :	-0.067	-0.200	0.091	-0.1	0.200	0.143	A	0.545	0.556 :	0.550		A	0	0.212	0.071	0.094	
		C	-0.500 :	-0.1	0.333	-0.333	-0.1	0	0	C	-0.333	-0.333 :	-0.333		C	0.333	-0.286	0.167	0.071	
		PCm	-0.417 :	-0.667	-0.667	0	-0.667	-0.500		PCm	0.334	0.334 :	0.334		PCm	0.467	0.257	0.334	0.353	
Jimmy	40	P	0.250 :	0	0	1	0.500	0	0.500	58	P	1	0.750 :	0.875	22	P	1	1	1	40
		A	0.132 :	-0.200	-0.143	0.333	0.600	0	-0.231	0.231	A	0.714	0.385 :	0.550		A	0.059	0.818	0.559	
		C	0.222 :	-0.1	1	0.333	0	0	0.667	0.600	C	1	-0.667 :	0.167		C	0.333	1	0.778	
		PCm	0.236 :	-0.500	0.500	0.667	0.250	0	0.584	0.800	PCm	1	0.042 :	0.521		PCm	0.667	1	0.889	
Lawrence	30	P	-0.135 :	-0.143	-0.333	0	-0.333	0	0	83	P	0.429	0.714 :	0.572	0	P	0.538	0.692	0.677	37.7
		A	0.182 :	0.176	0.231	0.200	0.375	-0.091	-0.143	-0.200	A	0.231	-0.267 :	-0.081		A	-0.043	0.032	-0.022	0.111
		C	0	0	0	0	0	0	0	0	C	0	-0.1	-0.500		C	0.375	0.538	0.111	0.341
		PCm	-0.068 :	-0.072	-0.167	0	-0.167	0	0	0.500	PCm	0.215	-0.143 :	0.036		PCm	0.457	0.615	0.456	0.509
Tarini	30	P	-0.139 :	1	-0.333	-0.500	0	0	0	58	P	-0.333	0.077 :	-0.128	22	P	0.778	-0.800	0.778	252
		A	0.003 :	-0.037	-0.130	-0.111	0.053	0.333		A	-0.128	0.077 :	-0.026		A	0.158	-0.083	0.800	0.292	
		C	0.111 :	1	0	0.333	0	0	0		C	-0.091	1	0.455		C	-0.167	0.636	1	0.490
		PCm	-0.014 :	1	-0.500	-0.250	0	0		PCm	-0.212	0.539 :	0.164		PCm	0.306	-0.082	0.889	0.371	
Nana	20	P	-0.067 :	-0.600	-0.667	0.666	0	0	0	33	P	-0.714	0.667 :	-0.024	56	P	1	0.200	0.778	36.3
		A	-0.107 :	-0.200	-0.143	-0.273	-0.200	-0.200		A	0.857	0.176 :	-0.341		A	0.222	-0.222	0.077	0.026	
		C	0.167 :	-0.1	1	1	0	0	0		C	-0.333	1	0.334		C	-0.1	-0.1	-0.1	0.026
		PCm	0.050 :	-0.800	-0.400	0.167	0.833	0.500	0		PCm	-0.524	0.834 :	0.155		PCm	0	-0.400	-0.111	-0.170
Ronald	30	P	0.144 :	0.333	0.333	0.200	0	0	0	33	P	0.714	0.333 :	0.524	44	P	1	1	1	35.7
		A	0.091 :	0.048	0.048	0.250	0.111	-0.111		A	0.111	0.200 :	0.156		A	0.040	0.364	0	0.135	
		C	0.089 :	-0.333	0.333	0.200	0	0	0		C	-0.429	0.429 :	0		C	-0.027	-0.167	-0.385	-0.193
		PCm	0.117 :	0	0.167	0.333	0.200	0		PCm	0.143	0.381 :	0.262		PCm	0.487	0.417	0.308	0.404	
Penelope	40	P	-0.167 :	0	-0.333	-0.333	0	0	0	50	P	-0.333	-0.667 :	-0.500	11	P	-0.778	0	0.636	33.7
		A	-0.156 :	-0.158	-0.333	0	0	-0.111	-0.250	-0.040	A	-0.415	-0.091 :	-0.253		A	-0.867	-0.067	0.286	-0.216
		C	-0.500 :	-0.1	-0.333	-0.333	0	-0.333	-0.1	0	C	0	-0.1	-0.500		C	1	-0.1	-0.1	-0.333
		PCm	-0.333 :	-0.500	-0.667	-0.333	-0.333	-0.167	-0.750	-0.500	PCm	-0.167	-0.834 :	-0.501		PCm	0.111	-0.500	-0.182	-0.190
Alan	40	P	0.444 :	0.333	1	0.333	0	0	0	17	P	0.667	0.333 :	0.500	33	P	1	0.600	0.778	30
		A	0.300 :	0.143	0.429	0.333	0.120	0.444	-0.333	-0.024	A	0.259	0.067 :	0.163		A	0.130	0.048	0.455	0.211
		C	0.606 :	0.533	0.333	0.667	0.600	0.333	1	0.714	C	0.818	0.714 :	0.766		C	1	0.600	0.333	0.644
		PCm	0.525 :	0.433	0.667	0.834	0.467	0.250	0.500	0.875	PCm	0.743	0.524 :	0.634		PCm	1	0.600	0.556	0.719
Jonathan	50	P	0.156 :	0.600	-0.333	1	-0.333	0	0	25	P	0.429	-0.250 :	0.090	11	P	1	0.385	0.556	28.7
		A	0.069 :	0	0.091	0.167	0.158	0	0	0.091	A	-0.067	0.043 :	-0.012		A	0.280	0.400	0.176	0.285
		C	0.195 :	-0.500	1	0	-0.333	0	1	0.600	C	0.750	0.200 :	0.475		C	0.539	0.571	0.833	0.648
		PCm	0.175 :	0.050	0.334	0.500	-0.333	0	0.500	-0.250	PCm	0.590	-0.025 :	0.283		PCm	0.770	0.478	0.695	0.648

Children	% Score	TASK A								TASK B				TASK C				TOTAL % SCORE [ASD]	
		Sets : 1-6m :		Handedness ratios/Sets						% Score	1	Sets 2	1	% Score	3	1-3			
		1	2	3	4	5	6	7	8										
Jessica	40	P .457 : .143	1	.333	.600	1	-.333			42	P .412	-.333	: .040	0	P -.778	-.778	-.556	: -.704	27.3 [-10]
		A .091 : .125	.053	.059	.167	.091	.048				A .301	-.300	: -.105	A .571	-.538	-.500	: -.536		
		C .250 : .333	.500	.333	.333	0	0				C -.333	.667	: .167	C .667	.692	1	: .342		
		PCm .354 : .238	.750	.333	.467	.500	-.167				PCm .040	.167	: .104	PCm -.723	-.043	.222	: -.181		
Ellen	40	P .020 : -.333	-.091	.200	.143	.200	0	-.143	-.429	42	P .667	-.667	: 0	0	P .091	.200	.333	: -.208	27.3 [-16]
		A -.047 : -.200	-.143	.250	0	.143	-.333	-.455	-.143		A -.212	-.333	: -.273	A .100	-.077	.200	: .074		
		C .168 : -.250	-.250	-.077	-.231	0	-.200	0	-.467		C -.250	.714	: -.482	C -.077	-.857	-.833	: -.589		
		PCm -.074 : -.292	-.171	.062	-.044	.100	-.100	-.072	-.448		PCm .209	-.691	: -.241	PCm .007	-.329	-.250	: -.191		
Warren	30	P .444 : .333	1	.333	1	0	0	0		50	P .750	.714	: .732	0	P 1	1	1	: 1	26.7 [0]
		A .429 : .231	.714	.176	.500	.500	.455				A .259	.125	: .192	A .273	.529	.667	: .490		
		C -.278 : -.1	0	-.1	.333	0	0	0			C 0	1	: .500	C 1	1	1	: 1		
		PCm .083 : -.334	.500	-.334	.667	0	0				PCm .375	.857	: .616	PCm 1	1	1	: 1		
Robert	40	P .350 : .600	1	.500	0	0	0	0		25	P 1	1	: 1	11	P .556	.385	.750	: .564	25.3 [-2]
		A .381 : .500	.412	.368	.200	.375	.429				A .806	.707	: .757	A .389	.053	0	: .147		
		C .689 : 1	1	1	-.200	.333	1	1			C 1	1	: 1	C 1	.385	1	: .795		
		PCm .520 : .800	1	.750	-.100	.167	.500				PCm 1	1	: 1	PCm .778	.385	.875	: .679		
Amelia	50	P .617 : .273	.500	1	.429	1	.500	.555	.200	25	P 1	.333	: .667	0	P 1	1	.800	: .933	25
		A .010 : .217	.231	-.176	.040	-.143	-.111	-.111	-.077		A .056	.158	: .107	A -.130	.524	-.280	: .225	[-4]	
		C .056 : .500	-.1	.333	.500	0	0	0	-.1		C .200	.667	: .434	C .667	0	-.385	: .094		
		PCm .337 : .387	-.250	.667	.465	.500	.250	-.223	.267		PCm .600	.500	: .550	PCm .834	.500	.208	: .514		
Simone	10	P .276 : .667	.200	.333	.167	.143	-.143			50	P -.111	.667	: .278	0	P 1	1	1	: 1	20 [-11.5]
		A .272 : 1	.636	.600	0	.143	-.750				A 0	.539	: .270	A .636	-.161	.636	: .370		
		C -.032 : 0	.143	0	0	-.333	0	0			C -.1	.556	: -.222	C 1	.714	-.833	: .294		
		PCm .122 : .334	.172	.167	.084	-.095	.072				PCm -.556	.612	: .028	PCm 1	.857	.084	: .647		
Lucy	20	P .111 : 1	.333	-.333	-.333	0	0	0		33	P -.600	.333	: -.134	0	P 1	1	1	: 1	17.7 [-26]
		A .335 : .158	.500	.600	.500	.250	0	0			A .180	.500	: .340	A .188	.500	.545	: .411		
		C .611 : .333	.333	1	1	1	0	0			C .143	1	: .572	C 1	1	.500	: .833		
		PCm .361 : .667	.333	.334	.334	.500	0				PCm -.229	.667	: .219	PCm 1	1	.750	: .917		
Sean	30	P .111 : .333	-.333	.333	.333	0	0	0		17	P 1	.667	: .834	0	P -.250	.400	.556	: .235	15.7 [+1]
		A .040 : -.273	0	.091	-.077	0	.500				A -.188	.231	: .022	A -.467	0	.238	: -.076		
		C .500 : 1	-.1	1	1	1	0	0			C -.333	0	: -.167	C -.250	-1	-.818	: -.689		
		PCm .306 : .667	-.667	.667	.667	.500	0				PCm .334	.334	: .334	PCm -.250	-.300	-.131	: -.227		
Arthur	10	P .490 : .273	.333	.333	1	1	0	0		17	P .429	.200	: .315	0	P 1	.600	.600	: .733	9
		A .131 : .030	0	.077	.333	.200	.143				A .450	0	: .225	A .125	.067	.290	: .161	[-1]	
		C .250 : .333	.333	.333	.500	0	0	0			C 1	.778	: .889	C .400	.867	.895	: .721		
		PCm .370 : .303	.333	.333	.750	.500	0				PCm .715	.489	: .602	PCm .700	.734	.748	: .727		

B.2 DATA: ERRORS IN TASKS A-C

ERRORS IN TASK A (PICTURE SEQUENCES)

	Set 1	Set 2	Set 3	Set 4	Set 5	Set 6	Total
[Presentation order:	3-1-2	1-3-2	2-1-3	2-3-1	2-1	2-1]	
Number of children (hearing, deaf) who made errors:	<u>42</u> (27,15)	<u>43</u> (27,16)	<u>43</u> (28,15)	<u>44</u> (26,18)	<u>18</u> (11,7)	<u>24</u> (16,8)	<u>54</u> (35,19)
In exact order of presentation**	15 (9,6)	14 (8,6)	17 (13,4)	18 (13,5)	18 (11,7)	22* (16,6*)	44 (30,14)

[Numbers refer to the correct sequence of events, with 1 as the first event.]

*Two deaf children who made errors in set 6 placed only one of the two cards on the board.

**The numbers of children who placed objects in the presentation order are an underestimation. Not included in the counts shown in the tables for Task A-C are placements that were not in a left-first to right-last order on the board. (Instead, for example, the top card was placed first but at the right, the next at the left, and the bottom card last in the middle.) Nor do the numbers account for other placements in the order of contact, such as when the pile of cards was kept face-down, resulting in adherence to the reverse presentation order. Some children rotated a pile during placements or worked alternately from the top and the bottom; some removed the circus cutouts from the envelopes not all together but one-by-one, and randomly. Objects (and shoulder straps) dropped, felt shapes tended to stick together, sneezes interrupted actions, etc.! (See Chapter 6 for descriptions of children's individual styles.) Such numerous variations, to be expected when children are the research subjects, necessitate eliminations, resulting in lower incidences reported.

ERRORS IN TASK B (SIZE PROGRESSIONS)

[Presentation order:	Set 1 (clowns) 3-1-4-6-5-2	Set 2 (dogs) 2-6-3-4-1-5]	Total*
Number of children (hearing, deaf) who made errors:	<u>32</u> (19,13)	<u>44</u> (26,18)	<u>45</u> (27,18)
<u>Single errors</u>	<u>14</u> (7,7)	<u>18</u> (13,5)	<u>28</u> (17,11)
Transposition of adjacent objects	7 (4,3)	9 (7,2)	15 (10,5)
--final pair (6-5)	6 (3,3)	3 (3,0)	9 (6,3)
--central pair (4-3)	1 (1,0)	4 (3,1)	5 (4,1)
--other pair (5-4)	0	2 (1,1)	2 (1,1)
Other misplacement [1-2-3- <u>6</u> -4-5]	7 (3,4)	9 (6,3)	15 (8,7)
<u>Other errors</u>			
With placements vertical	2 (0,2)	1 (0,1)	3 (0,3)
In presentation order	9 (7,2)	13 (5,8)	19 (10,9)
--exactly	0	5 (2,3)	5 (2,3)
--with one alteration [3-6-1-4-5-2]	3 (3,0)	7 (2,5)	10 (5,5)
--by first/last three [1-3-4/-2-6-5]	6 (4,2)	1 (1,0)	6 (4,2)
With largest two in centre [1-2- <u>5</u> -6-4-3]	5 (2,3)	4 (2,2)	8 (4,4)
Randomly within smallest and largest groups [3-2-1/-4-6-5]	5 (3,2)	5 (2,3)	10 (5,5)

With correct first and last placements	<u>24</u> (13,11)	<u>28</u> (20,8)	<u>40</u> (25,15)
--of smallest first	16 (9,7)	17 (11,6)	23 (14,9)
--of largest last	1 (0,1)	1 (1,0)	2 (1,1)
--of both smallest first and largest last**	7 (4,3)	10 (8,2)	15 (10,5)
With correct seriation of objects into the envelope	<u>2</u> (2,0)	<u>1</u> (1,0)	<u>3</u> (3,0)

[Numbers refer to the size of the objects, from 1 as the smallest to 6 as the largest. Examples of errors are from set 1.]

*Note that the totals are of the numbers of *children*. Thus, the children who made the same error in both sets are counted once in the totals, but when the errors are not mutually exclusive, the children are counted within each set and in the subtotals for each specific error made. Children who made at least one error in both sets of Task B total 31 (52% of the children in the study).

**Numbers are doubled for the totals of correct first and last placements.

ERRORS IN TASK C (PATTERN CONTINUATIONS)

[Presentation order:	Set 1 (BRY) YBRBYBRR	Set 2 (GWB) GGBWwBWBGW	Set 3 (stc) tctsscst]	Total*
Number of children (hearing, deaf) who made errors:	<u>31</u> (18,13)	<u>45</u> (28,17)	<u>31</u> (20,11)	<u>47</u> (30,17)
In nonlinear pattern	<u>0</u>	<u>0</u>	<u>1</u> (0,1)	<u>1</u> (0,1)
In presentation order	<u>7</u> (2,5)	<u>6</u> (3,3)	<u>10</u> (6,4)	<u>16</u> (8,8)
--exactly	<u>4</u> (2,2)	<u>4</u> (3,1)	<u>3</u> (2,1)	<u>8</u> (5,3)
--with one alteration [YBRBYRYBR]	3 (0,3)	2 (0,2)	7 (4,3)	10 (4,6)
With trick shape (w) included	NA	<u>28</u> (18,10)	NA	
--within pattern		<u>23</u> (14,9)		
--at right end		5 (4,1)		
By matching attributes	<u>15</u> (9,6)	<u>20</u> (11,9)	<u>15</u> (9,6)	<u>25</u> (14,11)
--in 2-3 triplets [YYY/RRR/BBB]	<u>2</u> (1,1)	<u>3</u> (3,0)	<u>1</u> (1,0)	<u>4</u> (3,1)
--in 2-4 pairs [YBBRYBRR]	13 (8,5)	17 (8,9)	14 (8,6)	21 (11,10)
<hr/>				
With correct placement				
--of the first shape within triplets x3 [BYR/BRR/BYY]	7 (5,2)	15 (9,6)	2 (2,0)	19 (12,7)
--into triplets with different attributes x3 [BRY/BYR/YBR]	16 (9,7)	16 (11,5)	11 (9,2)	29 (19,10)
--with W centred x3 [GWG/BWG/BWB]	NA	9 (7,2)	NA	

[Y = yellow, B = blue, R = red, G = green, W = white, t = triangle, c = circle,
s = square; w = small white circle (trick shape)]

NA = not applicable

*Of the children who made errors in Task C, 24 (51%) had at least one error in
all three sets, 12 (26%) in two sets, and 11 (23%) in one set.

APPENDIX C

CLASP-CLAP STUDY

The ways in which the handedness questionnaires were completed by the parents of the children in the Preliminary Study and in the Main Study raised suspicions about the reliability of the responses. An impression was that compared to the parents of the hearing children, the parents of the deaf children showed greater consistencies: The separate forms for the mother and the father seemed more often to have been completed by the same person, and there were more ticks straight down a column in their replies. It was speculated that there could have been some general difference in the attitudes of the parents towards the questionnaire: For the parents of the hearing children in the primary school nursery, the questionnaire could have been considered a novelty, and for the parents of the hearing children in the Psychology Department nursery, it might have been seen as a reciprocity obligation. For the parents of the deaf children, however, it was probably another unsolicited obligation, i.e. yet something else to be done.¹

To examine the consistency within the two parent groups, a count was made of the clasp and clap responses that were identical for the mother and the father, i.e. if both parents reported the same upper thumb when clasping hands and also the same upper hand when clapping. In the responses of the parents whose children are deaf, 73% (for 19 of the 26 pairs) are identical; in diametric contrast, 72% of the responses of the hearing children's parents (for 33 of the 46 pairs) are different. This discrepancy is in spite of the same distribution in both groups of their reported handedness: 88.9% of the parents of the deaf children and 88.3% of the parents of the hearing children reported they are right-handed. (The remaining 11% with deaf children are all left-handed; of those with hearing children, 7% are

¹See Oppenheim (1966) about the fallibilities of questionnaires, and van der Spuy, Fundudis, Kolvin, and Tweddle (1979) about agreement in the responses of parents of profoundly deaf children. (The uniformity of the 'angelic' answers of these parents, in significant contrast to the responses of other parents, could reflect an idealised expectation contrary to reality -- a by-product of a coping mechanism already strained, or a resignation.)

left-handed and 4% are ambidextrous.)²

The questionnaire responses of the two parent groups were compared with the observed responses of a group of University students.³ The hypothesis was that the hand clasp and clap responses of the students would resemble the responses of the parents of the hearing children. As shown in the following table, this was the case: The responses of the student group were more like those of the parents of the hearing than of the deaf children.

CLASP AND CLAP RESPONSES OF PARENTS AND STUDENTS

	Clasp		Clap		Clasp=clap	
	right	thumb up	right	hand up	r/l	up x2
	N	%	N	%	N	%
Parents/deaf children (54)	34	63	44	81	43	80
Parents/hearing children (94)	33	35	58	62	59	63
University students (112)	48	43	76	68	57	51

Additional comments:

1) All the observed hand clasps were with the fingers intertwined. As a rule, if only the thumbs are interlocked, and the fingers of each hand are together, the upper thumb will be the opposite of when the fingers are meshed. This could account for some differences between the questionnaire and the interview responses regarding the hand clasping positions. The different investigative methods might also have influenced the incidence of an equal-hand position when clapping, which was accepted during the interviews: at 7% in the students' observed responses versus at 2% in the written responses of each parent group.

2) About an undergraduate population three times larger[^]than the Edinburgh student group, Annett (1985) reported no significant

²The paired responses of the mother and father of each hearing and deaf child are similar to the questionnaire responses of parents of non-hearing-impaired children studied by Ross, Lipper, and Auld (1992): right-handedness for both parents in 78% and 76%, left-handedness in 1% and 2%, and one right-handed and one left-handed/ambidextrous parent in 21% and 22%, respectively. (The corresponding distributions among the parents of the hearing and deaf children in the thesis studies are, respectively, 78% and 77%, 2% and 0%, 20% and 23%.)

³The students were interviewed individually as they were leaving the dining hall of a University residence. Each was asked to clasp and clap his hands and, in addition, to fold his arms. Their handedness as they wrote their names (in a code) and as stated for themselves and others in their families was recorded. Of the 112 students, 90% considered themselves right-handed. The numbers of men and women students who participated were proportionate to the total numbers of men and women on full board: 60% of those interviewed and 61% of the students on full board were men. Most were undergraduates, from 17 different departments within seven faculties of the University of Edinburgh.

difference between right-handed and left-handed subjects in how they clasped their hands (and no difference in how they folded their arms). The proportion of right-handed subjects who clasped their hands with the left thumb up in that study agrees with this study: 54% and 55%, respectively. This clasping position was preferred, however, for 62% of their left-handed subjects, versus for 73% of the left-handed Edinburgh students.

3) Of the 112 students who responded, giving information about the handedness of others in their families (immediate and extended members, including grandparents and cousins), only one said he was adopted. This reported incidence of less than 1% could be a gross underrepresentation. In a House of Commons debate, it was said that up to 20% of people think their 'true father' is someone who biologically could not be (Barnes 1988). If this prevalence can be accepted, and if it can apply to this particular student group, about 21 students would be expected to have provided potentially inaccurate genetic information.

4) Another student was an exception in another way: She said that left-up and right-up thumb, hand, and arm positions were equally comfortable. Her explanation was that when she was a child, someone had noted that she was neglecting one side of her body, so had been trained to develop bilateral skills. (She has since had a Fulbright scholarship to study dance in Jamaica.) One other student was unusual by stating she never folds her arms.

5) Figures for the incidence of familial handedness are reported in a Chapter 3 footnote. (Analyses of the Main Study children's hand and arm positions, collected as part of the Handedness-Sidedness Inventory, have not yet been completed.)

6) A draft report of the clasp-clap data is attached.

REFERENCES

- Annett, M. (1985) *Left, Right, Hand and Brain: The Right Shift Theory*. London: Erlbaum.
- Barnes, R. (1988) Parliamentary proceedings: Human fertilisation and embryology, pp. 634-635 (4 February).
- Oppenheim, A.N. (1966) *Questionnaire Design and Attitude Measurement*. London: Heinemann.
- Ross, G., E. Lipper, and P.A.M. Auld (1992) Hand preference, prematurity and developmental outcome at school age. *Neuropsychologia* 30(5): 483-494 (May).
- van der Spuy, H.I.J., T. Fundudis, I. Kolvin, and E.G. Tweddle (1979) The hearing-impaired child of primary school age: background factors, maternal attitudes and maternal personality. Chapter

8, pp. 117-130, in T. Fundudis, I. Kolvin, and R. Garside (Eds), *Speech Retarded and Deaf Children: Their Psychological Development*. London: Academic Press.

IF YOU WRITE RIGHT...

Whether you write right-handed or left-handed predicts probabilities of how you clasp and clap your hands and fold your arms. The results were based on the responses of 260 adults, approximately equally divided between women and men and between those who completed a questionnaire and those who were observed in interviews. Those who consider themselves right-handed, and write with their right hands, account for 89.6% of the sample population, a proportion in accord with general population distributions. (During the interview survey, all the left-handers and 75% of the ambidextrals wrote with their left hands.) Almost half (45.5%) of those who are right-handed are men, yet among those who are left-handed or ambidextrous, there are twice as many men as women (18 versus nine).

In contrast to specific items on the questionnaire that were occasionally responded to as "both" or "either/or" (e.g. holding a hammer or toothbrush with their right or their left hand), the hand clasping and clapping and armfolding responses of the students showed a remarkable lack of ambivalence or hesitation. The strongest, most exclusive, preference was for the hand-clasp position, next the clap, and last the armfold. In fact, if invited to alter a position, subjects would usually pause, squirm, sometimes fail, and return to what they described as the more or only "comfortable/natural" position. Hence, it would seem reasonable to assume a fairly high degree of reliability and validity in these results.

As shown in the graph, the greatest differences related to general handedness preferences are in the upper hand when clapping (chi-square $p < 0.0001$): 72% of the right-handers clap with their right hand up, and 74% of the left-handers/ambidextrals clap with their left hand up, i.e. both with dominance consistency.⁴ The most homogeneous group is that with the smallest representation, the left-handed/ambidextrous women: All but one of the nine have a left-up hand clasp and hand clap position, and all five of the left-handed/ambidextrous University women have a left-up arm fold.

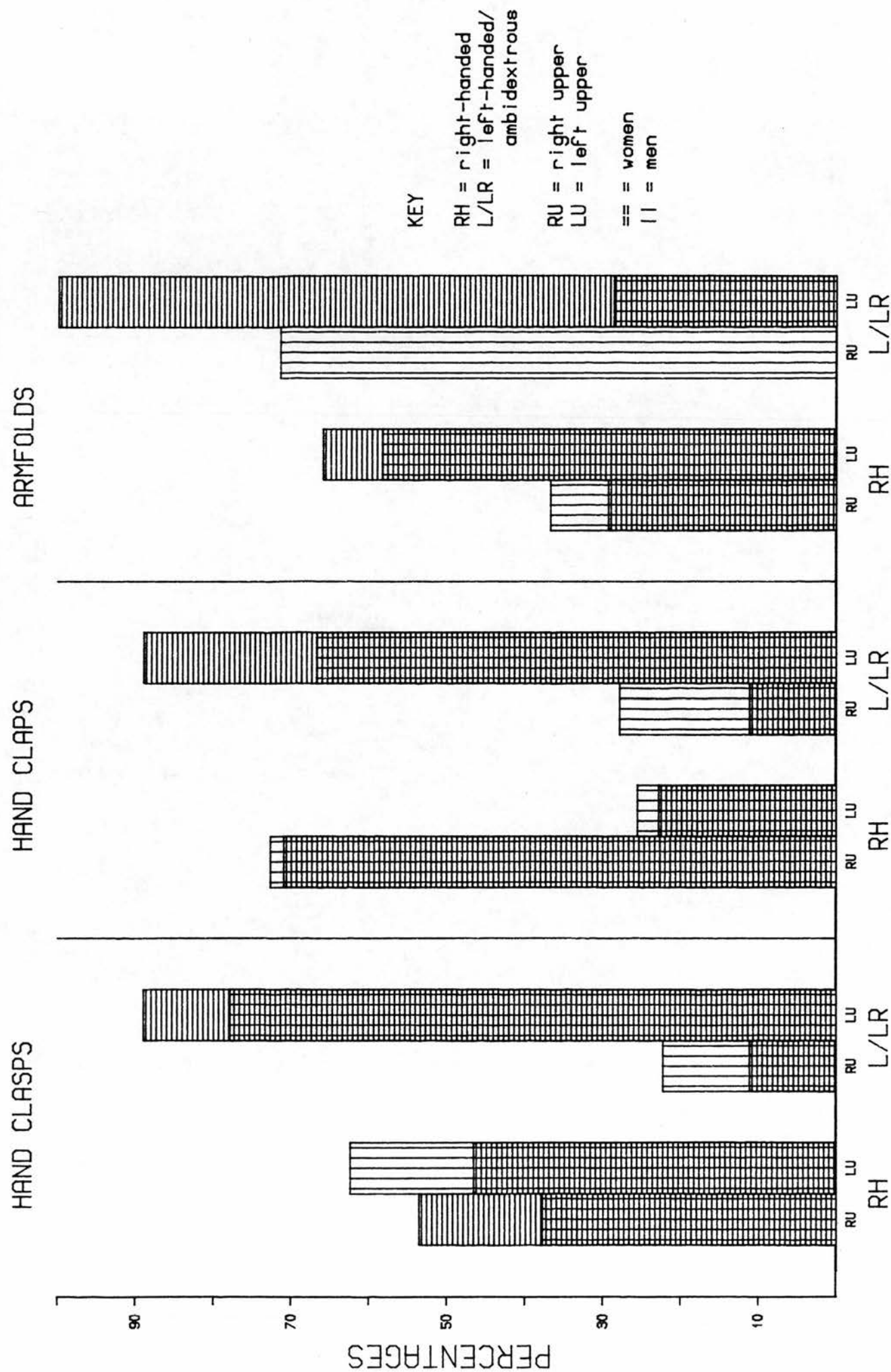
⁴Percentages reported and graphed omit low frequency combinations, i.e. claps and armfolds with both hands or both arms even. (This explains, for instance, why the graphed percentages for the right-handed men are higher than for the right-handed women in right- and left-hand-up clapping positions: 1.9% of the right-handed men versus 6.3% of the right-handed women have both hands symmetrical when clapping.) Armfold data were collected only for the observed subjects, the 112 University students.

In the hand clasps of right-handed women, the right thumbs are upper slightly more frequently than the left; however, for right-handed men, the left thumb is upper almost twice as often, and for the left-handers/ambidextrals, the left thumb is upper in a 4-to-1 left-right ratio.

With the clasp and clap measures combined, most right-handers show either a right- or left-clasp plus right-clap pattern, and most left-handers show a left-clasp plus left-clap pattern. For all who have a dominant hand clap, a right-clasp plus left-clap pattern is the least probable (6%).

When folding their arms, nearly twice as many right-handers had the left arm above the right arm rather than the reverse position. If an arm were grasped during the armfold (an incidence of just under 50%), the grasping hand corresponded to the person's identified handedness: right-handers' right hands grasping (73%), left-handers'/ambidextrals' left hands grasping (75%) -- again with a laterality compatibility.

To conclude: Whatever the mechanisms are that determine if you write right or write left, it would be wrong to underestimate their influence. There seems to be a strong link between the highly practiced skill of writing and the more subconscious and untaught acts of folding your arms, clasping and clapping your hands.



APPENDIX D

DEAFNESS

It is not enough to report how many deaf children placed all six of the clown cutouts with their right hands or got a score above 50%, or to report reports of the test results of other deaf children. To understand deaf children, it is necessary to understand deafness. While the 'psychology of deafness' cannot be summarized in this appendix, some information about what it can mean to be deaf will be presented to provide a context for interpreting the information reported in the chapters of this thesis.

Deafness is not only a condition of impaired hearing. In many ways the lives and thoughts of deaf people are affected by their hearing loss. Their experiences and their reactions to these experiences will be diverse, yet similar.

Inferences of what is 'normal' must refer to specific groups, as is recognized when standardized norms are established for different populations tested. Rather than considering 'the deaf' abnormal in comparison with hearing people, and mistaking a hearing-impaired person as an impaired hearing person, it is necessary to recognize homogeneities within deaf populations and resemblances between them and other specific populations. A 'deviance' relative to hearing people may be normal among deaf people; for them, the hearing world may be an abnormal social environment (Holm 1978, Furth 1973).

The families of most deaf people (approximately 90%) are hearing.¹ A 92% majority of the teachers of deaf children in the United States are hearing (Baldwin 1990); in Britain, where government regulations disqualify deaf people on medical grounds and require prior training within the general school system, there are even fewer deaf teachers (D. Scott and Hay 1981). Thus, within their families throughout life, as well as in their neighbourhoods during childhood and at their jobs when adults, many unoptional contacts of deaf people are with

¹Figures from a large survey conducted during the 1986-87 school year indicate that just over 6% of deaf children have either a mother or a father who is hearing impaired and that another 3% have both a hearing-impaired mother and father (Arthur Schildroth 1991, personal communication). A similar 88-90% is also estimated for those who are deaf and have hearing children (Schein and Delk 1974, Schein 1979).

hearing people.²

It has been with acceptance, not antagonism, that deaf people see themselves as living in two worlds, one hearing and the other deaf.³ Dual realities in everyday life -- both practical and emotional necessities -- are recognized:

Deaf people view speech and lip-reading as essential skills as well as wishing to use sign language for learning. (Kyle and Allsop 1982, cited in Kyle and Woll 1985, p. 46)

Long ago deaf people in America defeated a proposal for a colony of deaf people (Dimmock 1981); more recently, they have collectively declined inclusion in the U.S. Internal Revenue Service 'handicapped' category, actually lobbying *against* receiving a tax bonus (Furth 1973). While isolation is not desired, neither is discriminatory compensation, or pity or rejection.

DEAFNESS AND CULTURE

In their introductory sentence, Schlesinger and Meadow (1972, p. 1) acknowledge that implications of deafness have a wide impact:

Profound childhood deafness is more than a medical diagnosis: it is a cultural phenomenon in which social, emotional, linguistic, and intellectual patterns and problems are inextricably bound together.

Beyond a confusion of difference with deviance, there may be denial, if not simply ignorance, of a deaf culture, a community with its own identity, its own history and folklore, its own language, and its own perspectives on life. Cohesion within a deaf community is both subjective and structured, through organizations such as the British Deaf Association, the National Association of the Deaf and Deafpride in the United States; through local social clubs and societies, national and international conferences, journals, television programmes, Deaf Olympics, and national theatres of the deaf.

²Exceptions to these generalizations include placement in residential schools, where all the children and many of the dormitory counselors are hearing-impaired (e.g. all but one of the 16 counselors at my former school [Richard Steffan, Jr, 1992, personal communication]), and spouses, who for 86-92% of deaf people are also hearing-impaired (Schein and Delk 1974; Kyle and Allsop 1982, cited in Kyle and Woll 1985).

³This may be less true today than formerly. Militancy has solidified, as on the Gallaudet University campus in 1988: Through protest, a hearing person resigned her Presidency after one week in office and a deaf person was appointed (Orlans 1989).

Having a minority status, deaf people experience the repercussions of being different from the majority society -- the stigma, stereotypes, and perceived attitudes of indifference, discrimination, oppression, and ostracism.⁴ As a minority, deaf people "are victimized by situations that threaten the majority" (Vernon and Andrews 1990, p. 193) and may be made to feel inferior, dependent, and powerless (Schlesinger 1985, 1986, 1987a, 1987b, 1988, 1989). Worse still, if accepted and internalized, these denigrated self-estimations can be realized, affecting motivation to learn and academic proficiency (ibid.).

When a deaf person believes that "Deafness is seen as something bad in the outside world" (Ladd 1981, p. 424), Allport's (1954, p. 142) comment about prejudice and victimization would apply:

One's reputation, whether false or true, cannot be hammered, hammered, hammered, into one's head without doing something to one's character.

How cultural impressions can affect how one thinks and learns, which in turn determines how effective teaching will be, is discussed in the Deafness and Cognition section of this appendix. First, for an insight into the lives of deaf people, some personal experiences, then practices and policies in deaf education, are reported.

Accounts of Deaf People

Among the papers in the 1981 Scottish Workshop publication, 'The Integration and Disintegration of the Deaf in Society', there are personal histories of deaf people. Accounts are of their experiences of living "on the fringe of the hearing world" (Ladd 1981, p. 428), as foreigners (but without a country of their own) and as second-class citizens within the hearing society. Limitations are admitted:

Even one who is born with speech and hearing

⁴Goffman (1968) includes deaf people among those who are stigmatized because of differences incongruous with the stereotype of 'normality'. Although Ogbu (1978) and Neisser and others (in Neisser 1986) do not mention deaf people (omissions which according to R.A. Scott [1980] and Woodward [1982] are not atypical), their descriptions of minorities are relevant to an understanding of the sociological dynamics of minority people and the conflicts between cultures. Conflicts may be more multiple and more complex for deaf people: As they have a common language that differs from that of most of their parents and a less visible difference -- hence a greater option to select their affinities and identities and to elect their affiliations, analogies with ethnic minorities are questionable (Quigley and Kretschmer 1982). There are, however, resemblances between deaf people and people of ethnic minorities in the foundations of their cultures and in their reactions to afflictions.

unimpaired, and later becomes totally deaf has to admit that by the very nature of his handicap he can never develop well modulated speech with the tonal qualities that give it life. (Frame 1981, p. 390)

All I really want is to be able to join in normal conversation... but, despite being what schools call an 'oral success', despite a completely integrated life-style, this is what I will never be able to do. (Young 1981, p. 58)

Beyond the sensory and social deprivations and isolation experienced are fears, and testimonials, of a psychological genocide, one that "kills from within" (Ladd 1981, p. 419), in addition to policies that threaten deaf culture with extinction (e.g. Hay, Holmes, and Montgomery 1981).

Important individual changes are described: from coping by copying when in quasi integrated classes to developing confidence and self-esteem when within the deaf community; from pretenses when 'passing' or playing a Pygmalion role to discovery of alternatives that avoid unbearable situations that have devastating effects; from "the indignity of a communication imperialism" (Holmes 1981a, p. 402) and the constant strain "of toiling all the time to grasp what was said to keep in the swim" (Young 1981, p. 58) to release and relaxation when communicating in sign language with other deaf people; from assumption of a false identity as an inferior defective pseudo-hearing person to realization of an identity as a deaf person and fulfilment as a first-class deaf citizen.

A repeated wish is for there to be a change of attitude toward "the ultimate aim of enabling the deaf person to attain security, status and dignity" (Gibson 1981, p. 55), for there to be acceptance of "two cultures, not one and a half" (Ladd 1981, p. 422). Candide's Best of All Possible Worlds would be for hearing and deaf people alike to benefit from "the best of both worlds" (ibid., p. 431). Ideally there would be

One world at heart
And not a world
That's set apart!

(Madsen 1977, quoted in Young 1981, p. 66)

These and other documentaries (including Jacobs 1974, Davis 1976, Schowe 1979, Ashley 1985, and Bragg in Bragg and Bergman 1989) are biased. They are the views of deaf people, based upon their experiences. They are the indelible impressions of people who have been oppressed and whose language has been

suppressed.⁵ The anger expressed by some cannot be denied, but nor can the reasons for their anger be denied by those who are responsible. Hearing people who advocate methods contrary to the deaf consensus disavow the opinions of deaf people about their own preferences and needs, their judgments about their own destiny, and would deprive them of choice. Violating the democratic principle of Aristotle that "it is not the architect who is the best judge of a house but the man who dwells in it" (Dimmock 1981, p. iv), the Executive Director of a school for the deaf states,

...how biased can be the perspective of a handicapped person who tries to define his own social identity.
(Connor 1972, p. 525)⁶

Educational Practices and Policies

Contrary views about deafness are embedded and embroiled in educational issues. The centuries' old and universal controversy of oralism versus manualism, both in methodology and philosophy, is a major part of the present argument over

⁵There was in the past also a reluctance among deaf people to use their native language when communicating with hearing people. One reason was a fear of losing this most central bond between deaf people and with it their cultural identity: After the attempts to take away their language, there was next a threat that their language would be taken over by hearing people (Baker and Cokely 1980, Woodward 1982). Another factor was shame: Until the sign languages of deaf people were known to be more than pantomimes or uncoded gestures, but instead to be languages in their own right -- with a complex structure, a highly articulated grammar, and fundamental linguistic properties which define all languages (Klima and Bellugi 1979, Brennan 1987), they were deemed 'un-English' and, along with those who used them, were relegated an inferior status (Colville 1981, Loncke 1981, Vestberg 1989). An alternative to the viable reactions of resistance or acquiescence is accommodation, a more harmonious option that is evident today in the surge of, and demand for, deaf people as sign language instructors (Laura Gardner, personal communication).

⁶Connor's terms are indicative of his opinions: He speaks of 'a deaf subculture' and ghettos, of 'deafness' as "an outmoded concept" (p. 523), and of "the 'big lie'" about a deaf child: "that he always will remain a deaf person!" (p. 524, italics in the original), i.e. that he will moult his deafness and metamorphose into a hearing adult. Another administrator does not deny that one will be biased, stating, "I have already made my bias clear" (Lowell 1976, p. 33). Both, like other mortals, are selective in their choice of whose bias is to be credited; yet without documentation, they disregard the validity of objective studies and the opinions of a deaf person in determining what is "good for him" (Conrad 1976).

integration of deaf with hearing children within schools.⁷

Other contributors to the 1981 Scottish Workshop publication include eminent hearing and deaf educators from several countries who reiterate some of the circumstances, cultural distinctions, prejudices, discriminations, and condemnations described by deaf people (as those cited above) and that affect relationships between deaf and hearing people. They stipulate conditions necessary for integration to succeed (particularly at a primary/elementary school level, but through university education). Calculating that a child is in the classroom for only 8% or 10% of the year, Garretson (1981) and Jordan (1981) emphasize the importance of the children's total 'learning environment' and his development outwith the written curriculum.

Explicit reservations about integration concern the possibilities that the hearing hegemony will permeate further and perpetuate the 'normalisation conspiracy' (Merrill 1981); that speech and language skills will be expected to develop via osmosis and by emulation, with 'communication' through an interpreter (Garretson 1981, Jordan 1981) and 'learning' through borrowed lecture notes (Lawson 1981); that deaf children will be treated as classroom mascots (Montgomery 1981c) or converted into imitations -- at worst, caricatures, and at most, approximations -- of hearing persons; that they will be apart from rather than a part of normal school life; that instead of having their potential exploited and their unique abilities appreciated, they will be taunted and intimidated until they eventually become abnormal two-dimensional individuals who are "educationally, vocationally, and emotionally mutilated" (Garretson 1981, p. 164). Briefly, apprehensions are that 'mainstreaming' will be 'mai...ming'.

Their recommendations, and those of other professionals (educators, researchers, and therapists) include provisos: for decisions to be made with consultation, representation, and consent of the deaf community (e.g. Holmes 1981b), and that they not be governed overtly by geographic area or covertly by ethnocentrism; for recognition of the different needs and mental capacities of children within the 'handicapped' label

⁷The terms 'integration' and 'mainstreaming' have different connotations to different people and in different countries (Montgomery 1981a). In sign languages (both in Britain and in America), their images are divergent: The hands come together and the fingers mesh in the sign for 'integration'; the hands move confluent outward in the sign for 'mainstreaming'. Other terms used synonymously are 'normalisation' and 'decentralization' (Freeman, Carbin, and Boese 1981). The practice is similar whichever term is used and whatever the law enacted for implementation is called (e.g. Section 10 of the 1976 Education Act in Britain and Public Law 94-142, The Education for All Handicapped Children Act of 1975, in the U.S.).

(and the different needs of children within the 'hearing impaired' category, e.g. of the 95% prelingually deaf [Vernon 1976, 1981] and the others who were deafened, those who are multihandicapped, and those of a proportionally increasing ethnic minority [Reeves 1981]); for distinction between the social and communication barriers and the physical barriers that prevent 'equal access'; for procedures to safeguard against mere presence and proximity without participation and communication, against accentuation of differences and amplification of 'abnormalities'; for assurances that inequality is only numerical, and that the rights of the children -- hearing as well as deaf, the majority of deaf children as well as the elite -- to a 'free and appropriate' education are not compromised; for guarantees to go beyond the U.S. Supreme Court decision of 'minimum provision', "a floor of opportunity" (Moore, Cerney, and Garcia 1990), to maximization of individual human potentials; for measures to preserve the ideal of the legal mandate for 'the least restrictive environment' (re-defined as 'the most conducive learning environment' [NMAD 1985]) and prevent it from becoming the opposite -- the most restrictive environment (e.g. Meadow 1980, Davila 1981), a 'Dante's Inferno' (Vernon 1981), or 'an empty illusion' (Denton 1987); for immediate accountability and longitudinal documentation so that the policy is neither a 'placebo' (Montgomery 1981b) nor a misnomer (Moore and Kluwin 1986) or an hypocrisy (Merrill 1981), with the intended integration instead a *de facto* segregation and disintegration for deaf children while at school, or afterwards within society (Baldwin 1990).

What all would like to avoid, if it is possible, is for a deaf daughter, after years of instruction at home and in integrated classrooms, to say to her hearing mother,

'I don't want to hurt you, Mum, you do understand but you don't really. You don't know what it's like inside.' With these words she made a sign to indicate something deep within herself; translated, it means 'her being' or 'essential nature'. (Robinson 1991, p. 222)

Most researchers and leaders in the deaf community, however, agree that differences beyond the pathology of hearing impairment will remain (a fact for regret if one prefers a 'melting pot' society, for relief if one cherishes diversity among individuals within the society [Lane 1984]). Positive practices suggested to confront the gap between rhetoric and reality (Moore and Kluwin 1986) would include coalition and consortium arrangements and a multidisciplinary, collaborative team approach (e.g. Davila 1981, D. Scott and Hay 1981); innovations within residential schools, such as reverse mainstreaming (Schildroth 1986) and curricula to develop bilingual education (e.g. Conrad 1979; Freeman et al. 1981; Evans 1982; Stewart 1983; Quigley and Paul 1984; Johnson, Liddell, and Erting 1989).

Hopes are to achieve emancipation of deaf children without abolition of specialized schools, traditionally a mecca, the educational and social milieu of deaf people; to appreciate each individual without depreciating his language (Hansen 1980); to reward academic excellence without creating pseudosuperiorities or an oral intelligentsia (especially considering that most test results do not significantly correlate a deaf person's intelligence with the intelligibility of his speech, his ability to speechread words, his linguistic competence, or the degree of his hearing loss [Conrad 1975, 1979; Tervoort 1978; Meadow 1980; Evans 1982]).

Hopes are to overcome contradictions in practices, attitudes, and goals, such as permitting 'natural gesture' (Reeves 1976, Clark 1989) while prohibiting natural signs;⁸ endorsing

'the oral way of life'...a method which leads to the highest ideal in the education of a deaf child--normality of thought and expression (Braybrook 1976, p. 18)

but incompatibly quoting the first two objectives in public education to be

'the achievement of self realisation, the development of proper human relationships' (Lowell 1976, p. 33);

or speaking with a two-forked tongue of "the fight for full humanness" (Connor 1972) and of the "Whole Personality Approach to Oralism" (Reeves 1976) while changing the term 'deaf' to 'hearing-impaired' (Vernon 1976), the term 'partially deaf' to 'partially hearing' (in Britain in 1962 [Reed 1976]), then pejoratively abbreviating the label to 'a partial'.

Difficulties will be to correct counterproductive decisions, to redress the regressions, to resolve what Meadow (1980) has called an irony. We strived to improve the quality of deaf education by centralizing schools, obtaining a low teacher-student ratio, concentrating resources and services, constructing sound-proofed classrooms, providing individual speech instruction and auditory training and a range of

⁸Exceptions cited are for "a number of children who are not succeeding ...deaf people for whom the oral method is insufficient" (Braybrook 1976, pp. 19 and 21), "some of our children--for instance, those with multiple handicaps ...children who, because of some specific learning disability--visual handicap or late referral--have difficulty in lipreading and learning language" (Nicholas 1976, pp. 23 and 27), or ex-pupils, "to help them converse with their fellow deaf so long as they refrain from using it when they visit the school" (Reeves 1976, p. 13).

options in comprehensive programs within residential schools (Moore and Kluwin 1986). Then we legislated compulsory placement within large classrooms -- or in units/self-contained classrooms (too often converted work rooms or storage closets [Bernadette van Houten, personal communication]) in which a few children of widely varying ages, disabilities, and abilities are mixed (Braybrook 1976) -- within hearing schools, with inadequate facilities (e.g. without acoustic adaptations) and without specially trained staff or sufficient supportive services (for the children and their parents, or for the teachers, who are also under extra stress).

These are some of the challenges to be confronted in an endeavour to improve educational provisions and the general well-being of deaf children.

DEAFNESS AND COGNITION

The previous discussion of deafness and culture extends into the following discussion of deafness and cognition. As deafness affects a person's life and place in society, so also it affects his thoughts. And his thoughts are affected by how he communicates. Thus, the subjects of deafness, culture, cognition, and communication merge.

Deaf people have commented on cognitive differences they have perceived. Holmes (1981b, p. 364) says, "I am deaf. I cannot learn the way most people learn." Lawson (1981, p. 283) refers to a "slower tempo of thinking". Wright (1969, p. 58) also comments on slowness, saying, "The brains of deaf-born boys work slowly--inadequate grasp of language has to do with this--and can get locked for minutes on end in what seems monumental stupidity."⁹

Padden and Humphries (1988, p. 42) have described that for them "there is a different alignment, toward a different center". An example they give shows how the point of view will be different for different people: To deaf people, with themselves the central point of reference, a person who is

⁹Some delay in conversations is explained by the necessity of choosing between various alternative possibilities of what might have been said: There is "a quite appreciable time gap between the eye's reception of a word and the mind's interpretation or reading of it", also while taking in the next sentence or two and at the same time thinking of a reply (Wright 1969, pp. 63-64). Added to this fatiguing 'triple exercise' of speechreading is the presupposition of a sufficient vocabulary -- having to guess at, or bluff about, not only what each word is but also what it means. If a child who is not deaf must hear a word an average of forty times before it becomes a part of his expressive vocabulary, how many multiples of difficulty will there be for a deaf child who can neither hear a word spoken directly to him nor overhear all other words, those simply absorbed by hearing children. To Wright, who became deaf at the age of seven, "It is not hearing that one misses but overhearing" (ibid., p. 83).

'very hard-of-hearing' is "someone who can hear quite well" (pp. 40-41). The deviation from their perspective is great, so the meaning of the term is opposite that for hearing people. In their view, different languages are "intended for people with different biological characteristics ...different ways of thinking" (pp. 16 and 18).

It can be seen that not only in discussions about deafness and culture, and in disputes about deaf education, but also in investigations into the effects of deafness on cognition, a central issue is language.

The part language plays in our thinking can be antagonistic -- as when "language interferes with thought" (Samuel Taylor Coleridge, quoted in Vernon and Andrews 1990); it can be in a supportive role -- secondary to "visual understanding... the basis of all knowledge" (Thesoleidia, *ibid.*); it might have only a minor role -- as when Einstein said, "I very rarely think in words at all" (*ibid.*); or it can be cast as hero -- its starring role in some societies, and in most educational systems.

With whichever interpretation, the lines will be different if the actor is deaf. For him, spoken words will have little meaning: Auditory reception will be minimal and distorted, and worsened by high levels of noise; visual reception will be limited, for example, by distance and lighting and the number, familiarity, and personal features of the speakers (Rodda and Grove 1987). Comprehension will be dependent upon context, unspoken clues, and the person's linguistic knowledge of syntax, his vocabulary, and his abilities to anticipate, synthesize, and make sense of the fragments seen and heard -- all the mindreading parts of the act of speechreading (Frame 1981, Ladd 1981), the silent ad-lib parts said to consist of "ninety per cent guessword" (Wright 1969, p. 63). Natural for him will be to perceive visual information and to have his

language be one of signs.¹⁰ While sign language may be thought of by hearing people in one extreme as opprobrious (Vernon and Andrews 1990) or in the other extreme as fascinating (Ladd 1981, Vernon 1981), for most deaf people, it is simply the

¹⁰Throughout history, there have been efforts to devise ways of making speech visible, both aurally to disambiguate speech sounds and orally to aid pronunciation. Methods include the 17th Century phonetic transcriptions of Juan Pablo Bonet (Wright 1969, Lane 1984) and the fingerspelling glove of George Dalgarno (Stokoe 1974); later, A. Melville Bell's 'Visible Speech' symbols (Bell 1908) and Alexander Graham Bell's 'photophone' (which, although it failed, he insisted was "the greatest invention I have ever made; greater than the telephone" [Bruce 1988, p. 372]); and, more recently, R. Orin Cornett's coloured eyeglasses and Cued Speech method (Cornett 1976). Incentives for finding ways to clarify the reception and production of speech sounds through visual supplements stem from speechreading difficulties: The amount of what is said that is understood by the best speechreaders in the best of situations averages 26% (Vernon 1981) -- no more than "some crumbs of information" (Sheavyn 1976, p. 120). Over two-thirds of English speech sounds are estimated to be either invisible or visually indistinguishable, one from at least one other; phonemes that have the highest frequency incidence have the least visibility; vowels, although more identifiable than consonants in isolation, are less distinctive in continuous speech (Evans 1981 and 1982). Further difficulties arise in interpreting homophonous words and phrases. For example, you could easily confuse 'baby' and 'paper', so when asked, "Where's the baby?", you might reply, "I put it in the dustbin" (Wright 1969, p. 5). Likewise, your response would be different to phrases that have similar lip movements, e.g. "How do you do?" and "I love you" and "I'll have a few" (Philip Schmitt, personal communication; Vernon and Andrews 1990, p. 100). Did someone say, "We've discussed it" or "We're disgusted"? Is something 'not' or 'now', 'a never' or 'an ever' increasing problem? In current events, did the British Prime Minister speak of the 'prize' or the 'price' of an EEC single currency, and did the TV newsman say the Arabs and the Israelis are 'little nearer' or 'a little nearer' agreement? Such ambiguous messages would be more accurately conveyed by other visual means -- by writing, fingerspelling, and signing.

medium through which their thoughts are communicated.¹¹

Poizner (1981, 1983) has reported that formational elements of signs, specifically movement parameters, have a different perceptual salience for deaf and hearing adults, differences suggesting a modification of innate sensitivities based upon signed or spoken linguistic experiences -- possibly a "general consequence of acquiring a formal linguistic system" (1983, p. 693). Comparative judgments of the deaf subjects, who had acquired American Sign Language as their first and primary language, were weighted on those dimensions that are distinctive features of signs (at both lexical and inflectional levels), while the hearing subjects, who had no knowledge of sign language and lacked this reference, perceived other features of the signs as most salient.

A different use of language has been associated with cultural differences and the damage of attributed deficits. In a longitudinal study, following 40 profoundly deaf children into adolescence, and using Stanford test results to determine reading ability, Schlesinger (1988, 1989) found that 'crucially different' strategies in parental dialogue were reflected in the linguistic styles of their children and were related both to the children's reading levels and to

¹¹Deaf people who may be exceptions are those who identify more with hearing than with deaf people, particularly those who have less severe hearing losses and those who became deafened as adults (Schein 1979). In some groups, unanimous use of sign language has been reported: About a century ago, a deaf editor and President of the National Convention of Deaf-Mutes (Edwin A. Hodgson, cited in Lane 1984, p. 338) said,

...in the entire list of the deaf whom I know, there is not a leading man, successful in the world and polished intellectually, who does not know and use the language of signs. Moreover I have never known a case where signs had a harmful effect. Instead, they have stimulated the mind, inspired the spirit, and developed the natural capacities of the individual.

Brill (1976, p. 82) states,

To the best of my knowledge, every psychiatrist who is authoritative in this field recommends manual and Total Communication with deaf people as a means of preventing mental health problems. ...To the best of my knowledge, there is no psychiatrist or psychologist who recommends restricting deaf people to the exclusive use of oral modes of communication.

In my own experience (of 20 years, when working at a mental health service for deaf people and at schools for deaf children, visiting schools in Britain and France, studying at Gallaudet and taking courses at other universities), almost all of the prelingually deaf people I have met, whether from deaf or hearing families, not only use sign language but also consider it their natural and first language.

'advantaged' or 'disadvantaged' behaviours.¹²

As compared to mothers of deaf/Hi readers, mothers of deaf/Lo readers are more controlling, ask more test questions, repeat themselves more often, and drill letters, numbers, and colors. ...The mothers of deaf/Lo readers introduce a simple, concrete world populated by individual, static objects in the here-and-now. Their labels are primarily nouns...

The deaf/Lo readers transform or manipulate little of their parents' perceptual input. ...They remain in a world that emphasizes sensorial stimuli and concrete motor behaviors. The world of the senses has its glories for the appreciation of beauty, for savouring and describing the here-and-now, for descriptive poems, for rapping about the environment, but by itself is inefficient for modern school settings. (1989, pp. 16 and 18 of draft copy)

In contrast, the mothers of the better deaf readers use nouns and adjectives that are more abstract; they give explanations and ask 'if', 'when', and 'why' questions.

They not only describe the perceptual world but help their children to reorganize it, and to reason about or predict its multiple possibilities. (p. 18)

Such enriched communications have characteristics which resemble features other researchers have associated with general academic success, and have pervasive effects:

These divergent maternal approaches to communication also play important functions in children's psychological development, their sense of self esteem and their 'sense of control' over their environment. Dyadic communications have different impacts: one leading children into dialogue, the other into avoidance of communication first with parents, later

¹²In the original investigation, Schlesinger and Meadow (1972) identified different maternal behaviours that corresponded to the scores of the 40 deaf children on a composite 'Index of Communicative Competence'. The mothers of the communicatively competent children were rated as more flexible, more encouraging and approving, less didactic, and less intrusive when interacting with their children than were the mothers of the children who had poor communication skills. Ratings on these dimensions, and permissiveness, were significantly higher still for the mothers of 20 hearing children. Significant differences in the children were also apparent: On measures of being compliant rather than resistant, creative and imaginative, buoyant and happy, and showing enjoyment of interaction and pride in accomplishments, the hearing children had highest ratings, followed closely by the deaf children who communicated well, and followed with greatest difference by the deaf children who were less proficient in communication.

with other adults in authority. The former approach intensifies children's will to learn, the latter depresses it. (p. 19)

On the positive side, studies relate and equate greater cultural identity with higher cognitive functioning. Mediation of learning experiences by adults has successfully counteracted the effects of cultural deprivation and academic failure: Feuerstein's (1980) Instrumental Enrichment program of intervention, which in its original application altered the inferior performances of adolescents alienated from their own culture, has significantly improved the cognitive functioning of deaf children in the U.S. (Craig 1987a, 1987b). Deaf children whose thinking skills were developed with the materials and methods of this curriculum made gains in their Reading Comprehension and Math Computation scores that are significantly greater than those of the control subjects at the school, that are approximately double the national norms for Hearing-Impaired children, and in mathematics that are greater than the average gains of hearing children (ibid.). These results and others reported by Blennerhassett (1990) suggest that by accentuating abilities and focussing on cognitive processes, Feuerstein's techniques of assessment and teaching have benefits -- for high-functioning as well as for low-functioning students -- in expanding thinking strategies, improving academic performance, and promoting personal growth. Furth (1973) also found that "the intellectual development of deaf children in many instances resembles the development of children from culturally and socially impoverished areas" (p. 102), and that by teaching thinking skills, the 'experiential deficiency' and 'intellectual poverty' of deaf children can be compensated.

Studies of infant communications are also relevant. In the derivation of the word 'infant' ('in-', before, and 'fant-/fari-' to speak), a condition of infancy is associated with a condition of early deafness. Before infants are able, and expected, to speak, their communications with their mothers, or other caregivers, have features that are similar to the communications of deaf people. In the interactions of both mothers with their infants and deaf people with other deaf people, nonverbal aspects and simultaneous components of their communications have special importance.¹³

¹³Similar characteristics have been observed in the communications between profoundly mentally handicapped persons and their caregivers. Also without words, they express an awareness of and an emotional sensitivity to others. They are seen to regulate another's actions by showing signs of appreciation and aversion, by responding selectively to tone of voice, touch, and movements, and by reacting with laughter to unusual occurrences (Latchford 1989). Their movements when interacting with others have a high degree of synchronicity, measured in the regularity of beats in their exchanges, their 'dance' of initiations and responses (Burford 1988).

Typically, while communicating with their infants (but not with others), mothers will exaggerate their facial expressions, as with a curled-lip frown or open-mouthed and wide-eyed mock-surprise form of exclamation; gaze is prolonged, body position is forward, and touching is frequent (Stern 1977). Prosodics also are intensified, as by pitch changes from falsetto to bass, varied stress patterns, accelerations, crescendos, and sing-song syncopated intonation contours. Other alterations are in what is said: Nonsense sounds are invented, vowels and pauses are elongated, syntax is simplified, and utterances are shortened and repeated. The mother's vocalizations are attuned to the infant's sounds and rhythms of movement; affect and emotions are shared; communication is a communion in several contrapuntal modalities (ibid., also Stern, Hofer, Haft, and Dore 1985). The sequences of alternating vocalizations and pauses in which the mother and infant collaborate produce 'proto conversations' (Bateson 1979). Through these intersubjective exchanges, or 'metacommunications', of the early engagements and emotional attachments, culture is transmitted; information and references are conveyed, intentions and experiences are interpreted, meanings are derived, and symbolic language is conceived (Trevvarthen 1990).

There can be little wonder that hearing mothers of deaf infants often say they wish this period of interaction could have been extended (Lutterman 1987). However, unless the parents are deaf, once deafness has been diagnosed, the relationships between the parents and their infants are disrupted.

Gregory and Mogford (1981) have observed that hearing mothers whose mode of communication is spoken English do not play anticipatory games, such as 'peek-a-boo', with their deaf children; they deliberately elicit and train ('work on') the first words the child speaks; and, in comparison with the turn-taking exchanges of hearing mothers with their hearing children, they have more 'vocal clashes' with their deaf children. Analyzing the speech of eight oral hearing-impaired children from infancy to the age of four, these researchers found significant differences from the reported language development of hearing children both in the ages at which up to 100 words were acquired and in the words the children used (excluding two children, the two with the greatest hearing losses, who at age four had not yet reached the ten-word level). They considered that not only a reduced exposure to language but also fundamental differences originating in the preverbal communications might contribute to the deviant ways in which deaf children develop language.

Nienhuys and Tikotin (1983) categorized the pervasive behaviours of a hearing non-signing mother and her deaf infant as 'attending' (the mother also as 'eliciting', the infant also as 'averting'), in contrast to the 'play' and 'talk' activities characteristic of the hearing mother-infant dyad. In the rate of affect changes, they found that "the mother of the hearing-impaired infant appears to 'lead' her child...

whereas the mother of the hearing infant appears to 'follow' her infant" (p. 191). They suggest that hearing impairment may cause the mother "to adopt a strategy of monitoring and attracting her child's visual attention in order to maintain communication" (p. 192).

Wood, Wood, Griffiths, and Howarth (1986, and Wood 1982) discuss the danger of overcontrolling a deaf child's attention and actions. They identified "a more intrusive parental style and much higher levels of external control over the infant's experiences" (1986, p. 22) -- behaviours that seem to result from attempts to overcome the difficulties of 'divided attention':

To discover the relationships between a word and its referent, the deaf infant has to *remember* something he has just observed and deliberately *relate* this memory to another observation. In short, the deaf child with little or no auditory awareness has to do by intellect, *in sequence*, what 'happens' to the hearing baby in parallel. ...The deaf baby has to do much more, 'discovering' the relationships between two very different visual experiences that are displaced in time." (ibid., p. 22, italics in the original)

Deaf mothers when signing to (and on) their deaf infants adjust their ways of communicating. They seem to provide compensatory visual clues about content plus affect which could substitute for information expressed vocally through intonation variations. Woll and Kyle (1989) have observed that deaf mothers will alter the formation and placement of signs and will prolong the articulation of signs when modelling them for the child to imitate simultaneously. Meadow-Orlans and her colleagues (1986 and 1987, Koester and Meadow-Orleans 1990) have found differences in the facial expressions of deaf and hearing mothers and in the responses of their deaf infants: Deaf mothers when interacting with their deaf infants were much more likely to show positive facial affect; their infants tended to have a neutral affect while attending intently to their mothers' faces and hands, rather than to the surroundings.

Other prevalences reported among deaf mothers include an increase in physical contact with their infants and a 'match' of their expressions and actions to those of the infants (Meadow et al. 1987); a shorter mean length of utterance (interpreted as a possible attention-span adjustment) and movement of the hands and body that is constant rather than occasional and that is within a wider space (Ackerman and Kyle 1986); a far greater number of repetitions and a significantly greater number of acts by both the deaf mother and the infant that are related to and that directly follow those of the other (Gregory and Barlow 1986). Such variations are seen to optimize the quality of communication by contributing to mutual understanding and pleasure, and to the intellectual growth of the deaf infant.

From these variations, it is evident that simply saying or signing words is not sufficient -- that the manner in which a language is expressed is especially important. Were hearing parents of deaf infants to emulate deaf mothers, their own expertise ought not be diminished. The competence of the hearing parent, rather than being devalued, can be augmented, and without deference to or dependence upon others (including those in authority, the 'experts'). The established role of parent-as-provider need not be altered to one of parent-cum-teacher; it can be preserved and extended. Hearing parents can be encouraged to continue their natural 'motherese' language, which is congruent with their infants' comprehension abilities, and to incorporate into the receptive visual components of the early communications an added expressive manual component. Rather than intensifying the modal disparity between their vocal language and their infants' visual learning, they can accommodate their spoken language with sign supplements and not lose the qualities of the bonded relationship. With the step from gesturing to signing, the hearing parent is able to label objects and explain events, to make qualifications and associations, to refer to the past and future, and to relate cause and consequence, prediction and verification, actuality and possibility. In turn, with explicit information to aid him in interpreting his visual impressions, the deaf child will be less dependent upon his own inferences and able to experience the potency of language and the pleasure of communication.

A caveat to be repeated is that sign language and affective attunements are not a panacea to deafness. While they are antedotes that can lessen the risk that the thought processes of a deaf child will be restricted, or stunted, certain problems will remain. Physical proximity and visual attention will still be necessary for information to be received. But linked with an arbitrary word and an object seen, an iconic sign and affect signals can assist in ameliorating the problem of 'divided attention'. Language is, in whatever modality, built on repeated relevant associations, communication upon both understanding and being understood.

In later communications, positive effects have been reported by Wood et al. (1986, also Wood 1982 and 1991) when hearing teachers altered their styles of communicating with deaf children. In response to the teachers' decreased level of control, their asking fewer simple two-choice, yes-no (head-nod or head-shake), or wh-type questions, their interrupting less often for repairs to be imitated, and their contributing contingent information (non-verbally as well as verbally), commenting with phatic (emotional-social) expressions, and extending pauses, the children were more attentive, interested, and motivated (and more active). In turn, the children's replies were longer, more interesting, and showed greater initiative; they were also less comprehensible, and the actions potentially more reprehensible, to the teachers. In the view of these researchers (1986, p. 84),

...children can only be encouraged to communicate freely, readily and productively if they are allowed to do so, as far as practicable, in their own way. Any attempt to make them stop their physical activity is likely to depress their desire to communicate.

It is also their view that the basis of what has been described as an 'experiential deficiency' of deaf children is social and communicative; that impulsive and non-reflective behaviours and delayed levels of functioning are largely specific to tasks in which the deaf children's knowledge and competence are more limited; and that through participation in conversations and meaningful discourse, when contributions are encouraged, opportunities are exploited, and expectations are not lowered, then the children's understanding, diversity of thinking, and competencies will increase.

Support for the idea that improved communications contribute to higher cognitive functioning, as well as to better social adjustment, comes from studies of deaf children whose parents also are deaf.¹⁴ The levels of educational achievement have been consistently and significantly higher for the children whose parents are deaf than for the deaf children whose parents are hearing. On standardized language tests, their scores are significantly higher, even when the aetiology of deafness for both groups is genetic (thus ruling out the possibility of a higher incidence of neurological dysfunctions associated with exogenous aetiologies) and when many more of the children with hearing parents have received preschool education (Vernon and Koh 1970). In social and psychological development, their impulse-control scores (Harris 1978), their self-image scores and ratings for maturity, independence, and ability to take responsibility (Meadow 1968 and 1972, reported in Meadow 1980 and 1990) were likewise significantly higher and more positive. Also, the incidence of emotional/behavioural problems reported in a 1969-1970 annual survey was much lower for them than for deaf children who have

¹⁴It is important to interpret the results of these studies in reference to their dates. In this century, until about 1970, oral methods were used exclusively in all schools for the deaf in the United States. Thus, many of the studies that compare the performance of deaf children of deaf parents to the performance of deaf children of hearing parents were conducted before manual communication was recommended to parents and before it became the predominant mode for classroom instruction. Further wide-scale research would be necessary to determine the effects of a sign language environment at home and at school, i.e. the extent of differences between deaf children whose hearing parents and teachers communicate manually and deaf children whose parents are deaf. That there might now be less discrepancy is suggested, for example, in Montgomery's (1987) data: After total communication had been used in Scottish schools for more than ten years, there were substantial improvements on language tests over the performance of matched groups of children who had been taught orally.

one or more hearing parents (Stokoe and Battison 1981). On intelligence tests, i.e. on all five of the WISC-R performance subtests, the deaf children of deaf parents scored significantly higher not only in comparison with the deaf children of hearing parents but also in comparison with the norms for hearing children (Sisco and Anderson 1980).

The achievements of these deaf children are despite the lower educational level and lower occupational status of deaf adults in general (Schein and Delk 1974, Schein 1979). They are significantly greater when the deaf parents' communication mode is only oral (Corson 1973, discussed in Harris 1978), and when children whose deaf parents sign but are without good command of standard English are included in the comparative studies (Brasel and Quigley 1977).

Explanations of their achievements are related to the quality of communication between the deaf parents and their deaf children beginning in infancy and to the responses of the parents to having a deaf child. Deaf parents can be expected to experience less trauma and to react to what is known with less sense of crisis and with greater acceptance. A further advantage is their about five-months' earlier suspicion and the about nine-months' earlier confirmed diagnosis of their children's deafness (Harris 1978).

Recent studies indicate that the behaviours of deaf children of deaf parents are comparable to the behaviours of hearing children of hearing parents while interacting both with their mothers (seen in their similar separation behaviours, of attachment when younger and independence when older [Meadow-Orlans, Greenberg, and Erting 1990]) and with peers (seen in the comparable symbolic play behaviours of the toddlers [Spencer, Deyo, and Grindstaff 1990]). This implies that with congruent modes of communication, when parents experience less stress and feel competent of their abilities and confident that they both understand and are understood by their children, normal interactions may develop without conflict. Through these positive interactions and reciprocal communications, the auditory deprivation is compensated, and progress in other areas can evolve concomitantly. (For additional references and summaries, see also Schlesinger's Chapter 3 in Schlesinger and Meadow 1972, and Quigley and Kretschmer 1982; for the reactions of hearing parents, see, for example, McAree 1970 and Robinson 1991.)

CONCLUSION

From this description of some aspects of deafness, we may be more aware of how the experiences of deaf people are bound to influence what and how they think and learn. Although the deaf children who participated in the thesis studies are still young (from three to seven-and-a-half years old), their lives and minds will already have been affected by their deafness: by their decibel losses and the quality of their interactions with others.

REFERENCES

- Ackerman, J., and J. Kyle (1986) From gesture to language in the interaction of deaf babies and their mothers. Paper presented at the Language Development and Sign Language Workshop. Bristol (November).
- Allport, G.W. (1954) *The Nature of Prejudice*. Cambridge (MA): Addison-Wesley.
- Ashley, J. (1985) A personal account. Chapter 4, pp. 59-70, in H. Orlans (Ed.), *Adjustment to Adult Hearing Loss*. San Diego: College-Hill Press.
- Baker, C., and D. Cokely (1980) *American Sign Language: A Teacher's Resource Text on Grammar and Culture*. Silver Spring (MD): T.J. Publishers.
- Baldwin, S.C. (1990) Mainstreaming in retrospect: A deaf perception. *The Voice* 6(2): 14-17 (May/June).
- Bateson, M.C. (1979) 'The epigenesis of conversational interaction': a personal account of research development. Chapter 2, pp. 63-77, in M. Bullowa (Ed.), *Before Speech: The Beginning of Interpersonal Communication*. Cambridge: Cambridge University Press.
- Bell, A.G. (1908) *The Mechanism of Speech* (Third Edition). New York: Funk and Wagnalls.
- Blennerhassett, L. (1990) Intellectual assessment. Chapter 10, pp. 255-280, in D.F. Moores and K.P. Meadow-Orlans (Eds), *Educational and Developmental Aspects of Deafness*. Washington, D.C.: Gallaudet University Press.
- Bragg, B., and E. Bergman (1989) *Lessons in Laughter: The Autobiography of a Deaf Actor*. Washington, D.C.: Gallaudet University Press.
- Brasel, K.E., and S.P. Quigley (1977) Influence of certain language and communication environments in early childhood on the development of language in deaf individuals. *Journal of Speech and Hearing Research* 29(1): 95-107 (March).
- Braybrook, D.M. (1976) [Untitled] Chapter 3, pp. 18-21, in P. Henderson (Ed.), *Methods of Communication Currently Used in the Education of Deaf children* (Seminar Papers). London: Royal National Institute for the Deaf.
- Brennan, M. (1987) *British Sign Language: The language of the Deaf community*. Chapter 26, pp. 274-305, in T. Booth and W. Swann (Eds), *Including Pupils with Disabilities* (Curricula For All Series). Milton Keynes: Open University.

- Brill, R.G. (1976) [Untitled] Chapter 14, pp. 80-86, in P. Henderson (Ed.), *Methods of Communication Currently Used in the Education of Deaf Children* (Seminar Papers). London: Royal National Institute for the Deaf.
- Bruce, R.V. (1988) Alexander Graham Bell. *National Geographic*, **174**(3): 358-385.
- Burford, B. (1988) Action cycles: rhythmic actions for engagement with children and young adults with profound mental handicap. *European Journal of Special Needs Education*, **3**(4): 189-206.
- Clark, M. (1989) *Language Through Living for Hearing-impaired Children*. London: Hodder and Stoughton.
- Colville, M. (1981) The influence of British Sign Language structure on communication teaching techniques. Chapter 11, pp. 178-192, in B. Woll, J. Kyle, and M. Deuchar (Eds), *Perspectives on British Sign Language and Deafness*. London: Croom Helm.
- Connor, L.E. (1972) That the deaf may hear and speak. *Volta Review* **74**(9): 518-527 (December).
- Conrad, R. (1975) Commentary. Chapter 7, pp. 139-142, in N. O'Connor (Ed.), *Language, Cognitive Deficits, and Retardation*. London: Butterworth.
- (1976) Matters arising. Chapter 21, pp. 146-155, in P. Henderson (Ed.), *Methods of Communication Currently Used in the Education of Deaf Children* (Seminar Papers). London: Royal National Institute for the Deaf.
- (1979) *The Deaf Schoolchild: Language and Cognitive Function*. London: Harper and Row.
- Cornett, R.O. (1976) Cued Speech: What and Why? Chapter 7(b), pp. 41-44, in P. Henderson (Ed.), *Methods of Communication Currently Used in the Education of Deaf Children* (Seminar Papers). London: Royal National Institute for the Deaf.
- Craig, H.B. (1987a) Instrumental Enrichment: Process and results with deaf students. *Thinking Skills Newsletter*. Harrisburg: Pennsylvania Department of Education, Bureau of Curriculum and Instruction (Spring-Summer).
- (1987b) *Expanding Thinking Skills Through Instrumental Enrichment: Key Questions and Answers from the Video Interviews* (Instructional Manual). Pittsburgh: Center on Deafness, Western Pennsylvania School for the Deaf.
- Davila, R. (1981) Varieties of integration in the USA, Chapter

- 15, pp. 165-177, in G. Montgomery (Ed.), *The Integration and Disintegration of the Deaf in Society*. Edinburgh: Scottish Workshop Publications.
- Davis, C. (1976) [Untitled] Chapter 11, pp. 60-66, in P. Henderson (Ed.), *Methods of Communication Currently Used in the Education of Deaf Children* (Seminar Papers). London: Royal National Institute for the Deaf.
- Denton, D.M. (1987) Educational, social, technological and scientific trends and the deaf consumer (Section Leader's report). *American Annals of the Deaf* **132**(5): 322 (November).
- Dimmock, A. (1981) Foreword, pp. i-iv, in G. Montgomery (Ed.), *The Integration and Disintegration of the Deaf in Society*. Edinburgh: Scottish Workshop Publications.
- Evans, L. (1981) Psycholinguistic perspectives on visual communication. Chapter 9, pp. 150-161, in B. Woll, J. Kyle, and M. Deuchar (Eds), *Perspectives on British Sign Language and Deafness*. London: Croom Helm.
- (1982) *Total Communication: Structure and Strategy*. Washington, D.C.: Gallaudet College Press.
- Feuerstein, R. (with Y. Rand, M.B. Hoffman, and R. Miller) (1980) *Instrumental Enrichment: An Intervention Program for Cognitive Modifiability*. Baltimore: University Park Press.
- Frame, M. (1981) The testimony of Mark Frame, a bonnie fechter, Chapter 34, pp. 385-394, in G. Montgomery (Ed.), *The Integration and Disintegration of the Deaf in Society*. Edinburgh: Scottish Workshop Publications.
- Freeman, R.D., C.F. Carbin, and R.J. Boese (1981) *Can't Your Child Hear? A Guide for Those Who Care about Deaf Children*. London: Croom Helm.
- Furth, H.G. (1973) *Deafness and Learning: A Psychosocial Approach*. Belmont (CA): Wadsworth.
- Garretson, M. (1981) The unwritten curriculum. Chapter 14, pp. 153-164, in G. Montgomery (Ed.), *The Integration and Disintegration of the Deaf in Society*. Edinburgh: Scottish Workshop Publications.
- Gibson, L. (1981) Integration from a firm base. Chapter 6, pp. 51-55, in G. Montgomery (Ed.), *The Integration and Disintegration of the Deaf in Society*. Edinburgh: Scottish Workshop Publications.

- Goffman, E. (1968) *Stigma: Notes on the Management of Spoiled Identity*. Harmondsworth: Penguin/Pelican Books.
- Gregory, S., and S. Barlow (1986) Interactions between deaf babies and their deaf and hearing mothers. Paper presented at the Language Development and Sign Language Workshop. Bristol (November).
- and K. Mogford (1981) Early language development of deaf children. Chapter 14, pp. 218-237, in B. Woll, J. Kyle, and M. Deuchar (Eds), *Perspectives on British Sign Language and Deafness*. London: Croom Helm.
- Hansen, B. (1980) *Aspects of Deafness and Total Communication in Denmark*. Copenhagen: The Center for Total Communication.
- Harris, R.I. (1978) Impulse control in deaf children: Research and clinical issues. Chapter 8, pp. 137-156, in L. Liben (Ed.), *Deaf Children: Developmental Perspectives*. New York: Academic Press.
- Hay, J., M. Holmes, and G. Montgomery. Bicultural adaptation and survival: Integration or disintegration? Chapter 33, pp. 367-382, in G. Montgomery (Ed.), *The Integration and Disintegration of the Deaf in Society*. Edinburgh: Scottish Workshop Publications.
- Holm, C.S. (1978) Deafness: Common misunderstandings. *American Journal of Nursing* 78(11): 1910-1912.
- Holmes, A.M. (1981a) Segregated in the mainstream. Chapter 35, pp. 395-404, in G. Montgomery (Ed.), *The Integration and Disintegration of the Deaf in Society*. Edinburgh: Scottish Workshop Publications.
- (1981b) Integration on an equal footing - the need for deaf representation. Chapter 32, pp. 361-365, in G. Montgomery (Ed.), *The Integration and Disintegration of the Deaf in Society*. Edinburgh: Scottish Workshop Publications.
- Jacobs, L.M. (1974) *A Deaf Adult Speaks Out*. Washington, D.C.: Gallaudet College Press.
- Johnson, R.E., S.K. Liddell, and C.J. Erting (1989) *Unlocking the Curriculum: Principles for Achieving Access in Deaf Education* (Gallaudet Research Institute Working Paper 89-3). Washington, D.C.: Gallaudet University.
- Jordan, I.K. (1981) Integration and total communication in the education of deaf children. Chapter 4, pp. 37-43, in G. Montgomery (Ed.), *The Integration*

- and Disintegration of the Deaf in Society. Edinburgh: Scottish Workshop Publications.
- Klima, E.S., and U. Bellugi (with others) (1979) The Signs of Language. Cambridge (MA): Harvard University Press.
- Koester, L.S., and K.P. Meadow-Orlans (1990) Parenting a deaf child: Stress, strength, and support. Chapter 12, pp. 299-320, in D.F. Moores and K.P. Meadow-Orlans (Eds), Educational and Developmental Aspects of Deafness. Washington, D.C.: Gallaudet University Press.
- Kyle, J.G., and B. Woll (with G. Pullen and F. Maddix) (1985) Sign Language: The Study of Deaf People and Their Language. Cambridge: Cambridge University Press.
- Ladd, P. (1981) The erosion of social and self identity by the mainstream: A personal experience. Chapter 36, pp. 405-432, in G. Montgomery (Ed.), The Integration and Disintegration of the Deaf in Society. Edinburgh: Scottish Workshop Publications.
- Lane, H. (1984) When the Mind Hears: A History of the Deaf. New York: Random House.
- Latchford, G. (1989) Towards an Understanding of Profound Mental Handicap. Unpublished Ph.D. Thesis, University of Edinburgh.
- Lawson, L. (1981) Integration? Personal experience. Chapter 24, pp. 279-292, in G. Montgomery (Ed.), The Integration and Disintegration of the Deaf in Society. Edinburgh: Scottish Workshop Publications.
- Loncke, P. (1981) The philosophy of integration of the deaf in Flanders: A critical approach. Chapter 17, pp. 191-199, in G. Montgomery (Ed.), The Integration and Disintegration of the Deaf in Society. Edinburgh: Scottish Workshop Publications.
- Lowell, E.L. (1976) [Untitled] Chapter 5, pp. 30-34, in P. Henderson (Ed.), Methods of Communication Currently Used in the Education of Deaf Children (Seminar Papers). London: Royal National Institute for the Deaf.
- Lutterman, D. (1987) Deafness in the Family. Boston: Little, Brown and Company/College Hill Press.
- McAree, R. (1970) What price parenthood? Volta Review 72(7): 431-437 (October).
- Meadow, K.P. (1980) Deafness and Child Development. Berkeley: University of California Press.

Meadow-Orlans, K.P. (1990) Research on developmental aspects of deafness. Chapter 11, pp. 283-298, in D.F. Moores and K.P. Meadow-Orlans, Educational and Developmental Aspects of Deafness. Washington, D.C.: Gallaudet University Press.

-----, M.T. Greenberg, and C. Erting (1990) Attachment behavior of deaf children with deaf parents. Chapter 17, pp. 380-389, in D.F. Moores and K.P. Meadow-Orlans (Eds), Educational and Developmental Aspects of Deafness. Washington, D.C.: Gallaudet University Press. [Originally published in the Journal of the American Academy of Child Psychiatry **22**: 23-28, 1983.]

-----, C. Erting, C. Prezioso, F. Bridges-Cline, and R.H. MacTurk (1986) Effects of deafness on mother-infant interaction. Presentation at the Annual Meeting of the American Psychological Association. Washington, D.C. (August).

-----, R.H. MacTurk, C. Prezioso, C.J. Erting, and P.S. Day (1987) Interactions of deaf and hearing mothers with three- and six-month-old infants. Presentation at the Biennial Meeting of the Society for Research in Child Development. Baltimore, Maryland (April).

Merrill, E.C., Jr (1981) Normalisation or integration? The role of deaf people in education and society. Chapter 19, pp. 329-340, in G. Montgomery (Ed.), The Integration and Disintegration of the Deaf in Society. Edinburgh: Scottish Workshop Publications.

Montgomery, G. (1981a) Introduction, pp. v-xiii, in G. Montgomery (Ed.), The Integration and Disintegration of the Deaf in Society. Edinburgh: Scottish Workshop Publications.

----- (1981b) The ideal of a workshop with the deaf. Chapter 12, pp. 123-134, in G. Montgomery (Ed.), The Integration and Disintegration of the Deaf in Society. Edinburgh: Scottish Workshop Publications.

----- (1981c) In the wake of Warnock: Some reactions of the Scottish Workshop. Chapter 37, pp. 433-452, in G. Montgomery (Ed.), The Integration and Disintegration of the Deaf in Society. Edinburgh: Scottish Workshop Publications.

----- (1987) Then and now: Recording a language revolution in Scotland 1976-1987. Pp. 758-765, in One World, One Responsibility, Proceedings: X World Congress of the World Federation of the Deaf. Espoo, Finland.

- Moore, D.F., and T.N. Kluwin (1986) Issues in school placement. Chapter 5, pp. 105-123, in A.N. Schildroth and M.A. Karchmer (Eds), Deaf Children in America. San Diego: College-Hill Press.
- , B. Cerney, and M. Garcia (1990) School placement and least restrictive environment. Chapter 5, pp. 115-136, in D.F. Moore and K.P. Meadow-Orlans (Eds), Educational and Developmental Aspects of Deafness. Washington, D.C.: Gallaudet University Press.
- Neisser, U. (1986) The School Achievement of Minority Children: New Perspectives. Hillsdale (NJ): Erlbaum.
- Nicholas, S.M. (1976) [Untitled] Chapter 4, pp. 22-29, in P. Henderson (Ed.), Methods of Communication Currently Used in the Education of Deaf Children (Seminar Papers). London: Royal National Institute for the Deaf.
- Nienhuys, T.G., and J.A. Tikotin (1983) Pre-speech communication in hearing and hearing-impaired children. Journal of the British Association of Teachers of the Deaf 7(6): 182-194 (November).
- NMAD [New Mexico Association of the Deaf] (1985) N.M.A.D.'s position paper on PL 94-142. The Maryland Bulletin CV(3): 1-3.
- Ogbu, J.U. (1978) Minority Education and Caste: The American System in Cross-Cultural Perspective. New York: Academic Press.
- Orlans, H. (1989) The revolution at Gallaudet. Change 21(1): 9-18.
- Padden, C., and T. Humphries (1988) Deaf in America: Voices from a Culture. Cambridge (MA): Harvard University Press.
- Poizner, H. (1981) Visual and "phonetic" coding of movement: Evidence from American Sign Language. Science 212(4495): 691-693 (8 May).
- (1983) Perception of movement in American Sign Language: Effects of linguistic structure and linguistic experience. Perception and Psychophysics 33(3): 215-231.
- Quigley, S.P., and R.E. Kretschmer (1982) The Education of Deaf Children: Issues, Theory, and Practice. London: Edward Arnold.
- and P.V. Paul (1984) Language and Deafness. San Diego: College-Hill Press.
- Reed, M. (1976) Communication in deaf education. Chapter 6,

- pp. 35-37, in P. Henderson (Ed.), *Methods of Communication Currently Used in the Education of Deaf Children (Seminar Papers)*. London: Royal National Institute for the Deaf.
- Reeves, J.K. (1976) *The Whole Personality Approach to Oralism in the education of the deaf*. Chapter 2, pp. 9-17, in P. Henderson (Ed.), *Methods of Communication Currently Used in the Education of Deaf Children (Seminar Papers)*. London: Royal National Institute for the Deaf.
- (1981) Coordinated planning or makeshift improvisation? Styles of educational provision for deaf children. Chapter 22, pp. 251-260, in G. Montgomery (Ed.), *The Integration and Disintegration of the Deaf in Society*. Edinburgh: Scottish Workshop Publications.
- Robinson, K. (1991) *Children of Silence: The Story of Sarah's and Joanne's Triumph over Deafness*. London: Penguin Books.
- Rodda, M., and C. Grove (1987) *Language, Cognition and Deafness*. Hillsdale (NJ): Lawrence Erlbaum Associates.
- Schein, J.D. (1979) Society and culture of hearing-impaired people. Chapter 36, pp. 479-487, in L.J. Bradford and W.G. Hardy (Eds), *Hearing and Hearing Impairment*. New York: Grune and Stratton.
- and M.T. Delk, Jr (1974) *The Deaf Population of the United States*. Silver Spring (MD): National Association of the Deaf.
- Schildroth, A.N. (1986) Residential schools for deaf students: A decade in review. Chapter 4, pp. 83-104, in A.N. Schildroth and M.A. Karchmer (Eds), *Deaf Children in America*. San Diego: College-Hill Press.
- Schlesinger, H.S. (1985) The psychology of deafness. Chapter 7, pp. 99-118, in H. Orlans (Ed.), *Adjustment to Adult Hearing Loss*. San Diego: College-Hill Press.
- (1986) Reliance on self and others: Autonomy and the lessening of dependency of young deaf adults. Chapter, pp. 64-76, in D.H. Ashmore (Ed.), *Regional Conference on Postsecondary Education for Hearing Impaired Persons (Proceedings)*. Knoxville (TN): The Postsecondary Education Consortium.
- (1987a) Effects of powerlessness on dialogue and development: Disability, poverty, and the human condition. Chapter 1, pp. 1-27, in B.W. Heller, L.M. Flohr, and L.S. Zegans

(Eds), Psychosocial Interventions with Sensorially Disabled Persons. Orlando (FL): Grune and Stratton.

- (1987b) Dialogue in many worlds: Adolescents and adults - hearing and deaf. Chapter, pp. 13-30, in G.B. Anderson and D. Watson (Eds), Innovations in the Habilitation and Rehabilitation of Deaf Adolescents (Selected Conference Proceedings). Rehabilitation Research and Training Center on Deafness and Hearing Impairment, University of Arkansas.
- (1988) Questions and answers in the development of deaf children. Chapter 11, pp. 261-291, in M. Strong (Ed.), Language Learning and Deafness. Cambridge: Cambridge University Press.
- (1989) Developmental assessment in its infancy. In H.S. Luey, H.H. Elliott, and L.E. Glass (Eds), Mental Health Assessment of Deaf Clients: Special Conditions (Conference Proceedings). San Francisco: UCSF Center on Deafness.
- and K.P. Meadow (1972) Sound and Sign: Childhood Deafness and Mental Health. Berkeley: University of California Press.
- Schowe, B.M. (1979) Identity Crisis in Deafness: A Humanistic Perspective. Tempe (AZ): Scholars Press.
- Scott, D., and J. Hay (1981) Deaf teachers: Integration in the staff room. Chapter 28, pp. 317-325, in G. Montgomery (Ed.), The Integration and Disintegration of the Deaf in Society. Edinburgh: Scottish Workshop Publications.
- Scott, R.A. (1980) Foreword, pp. 7-10, in P.C. Higgins (Author), Outsiders in a Hearing World: A Sociology of Deafness. Beverly Hills: Sage Publications.
- Sheavyn, E.M. (1976) [Untitled] Chapter 18, pp. 119-122, in P. Henderson (Ed.), Methods of Communication Currently Used in the Education of Deaf Children (Seminar Papers). London: Royal National Institute for the Deaf.
- Sisco, F.H., and R.J. Anderson (1980) Deaf children's performance on the WISC-R relative to hearing status of parents and child rearing experiences. American Annals of the Deaf 125(7): 923-930 (October).
- Spencer, P.E., D. Deyo, and N. Grindstaff (1990) Symbolic play behavior of deaf and hearing toddlers. Chapter 18, pp. 390-406, in D.F. Moores and K.P. Meadow-Orlans (Eds), Educational and Developmental Aspects of Deafness.

Washington, D.C.: Gallaudet University Press.

Stern, D. (1977) *The First Relationship: Infant and Mother*. London: Fontana/Open Books.

-----, L. Hofer, W. Haft, and J. Dore (1985) Affect attunement: The sharing of feeling states between mother and infant by means of inter-modal fluency. Chapter 11, pp. 249-268, in T.M. Field and N.A. Fox (Eds), *Social Perception in Infants*. Norwood (NJ): Ablex Publishing Corporation.

Stewart, D.A. (1983) The use of sign by deaf children: The opinions of a deaf community. *American Annals of the Deaf* **128**: 878-883.

Stokoe, W.C., Jr. (1974) Classification and description of sign languages. [Unnumbered] Chapter, pp. 345-371, in T.A. Sebeok (Ed.), *Current Trends in Linguistics*, Volume 12. The Hague: Mouton.

----- and R.M. Battison (1981) Sign language, mental health, and satisfactory interaction. Chapter 12, pp. 179-194, in L.K. Stein, E.D. Mindel, and T. Jabaley (Eds), *Deafness and Mental Health*. New York: Grune and Stratton.

Tervoort, B.T. (1978) Bilingual interference. Chapter 5, pp. 169-240, in I.M. Schlesinger and L. Namir (Eds), *Sign Language of the Deaf: Psychological, Linguistic, and Sociological Perspectives*. New York: Academic Press.

Trevarthen, C. (1990) Signs before speech. [Unnumbered] Chapter, pp. 689-755, in T.A. Sebeok and J. Umiker-Sebeok (Eds), *The Semiotic Web 1989*. Berlin: Mouton de Gruyter.

Vernon, M. (1976) Communication and the education of deaf and hard of hearing children. Chapter 16, pp. 99-109, in P. Henderson (Ed.), *Methods of Communication Currently Used in the Education of Deaf Children (Seminar Papers)*. London: Royal National Institute for the Deaf.

----- (1981) Public law and private distress. Chapter 13, pp. 139-152, in G. Montgomery (Ed.), *The Integration and Disintegration of the Deaf in Society*. Edinburgh: Scottish Workshop Publications.

----- and J.F. Andrews (1990) *The Psychology of Deafness: Understanding Deaf and Hard-of-Hearing People*. New York: Longman.

----- and S.D. Koh (1970) Early manual communication and deaf children's achievement. *American Annals of the Deaf* **115**(5): 527-536 (September).

Vestberg, P. (1989) Beyond stereotypes: Perspectives on the

personality characteristics of deaf people (R.C. Johnson, Ed.) (Gallaudet Research Institute Working Paper 89-2). Washington, D.C.: Gallaudet University.

Woll, B., and J.G. Kyle (1989) Communication and language development in children of deaf parents. Chapter 7, pp. 129-144, in S. von Tetzchner, L.S. Siegel, and L. Smith (Eds), The Social and Cognitive Aspects of Normal and Atypical Language Development. New York: Springer-Verlag.

Wood, D.J. (1982) The linguistic experiences of the prelingually hearing-impaired child. Journal of the British Association of Teachers of the Deaf 6(4): 86-93 (July).

----- (1991) Communication and cognition: How the communication styles of hearing adults may hinder--rather than help--deaf learners. American Annals of the Deaf 136(3): 247-251 (July).

-----, H. Wood, A. Griffiths, and I. Howarth (1986) Teaching and Talking with Deaf Children. Chichester: Wiley.

Woodward, J. (1982) How You Gonna Get to Heaven if You Can't Talk With Jesus: On Depathologizing Deafness. Silver Spring (MD): T.J. Publishers.

Wright, D. (1969) Deafness. New York: Stein and Day.

Young, B. (with W.J. Madsen) (1981) One world at heart. Chapter 7, pp. 57-67, in G. Montgomery (Ed.), The Integration and Disintegration of the Deaf in Society. Edinburgh: Scottish Workshop Publications.

APPENDIX E

EXPERIMENT: A ONE-HANDED CONDITION

The possibility that a child's performance might improve if he could use only his preferred hand to sequence objects was explored recently when a German television producer wanted to film a child as part of a programme on 'Handedness'. Two children from the nursery in the Psychology Department participated in the experiment. Their mean age was four years, with George then three years and eight months old and Eilie four years and four months old. Both used their right hands to write their names. Everyone in their families is reported to be right-handed except for Eilie's father, who is left-handed. George has a younger brother; Eilie has a twin brother and a younger sister.

These children completed the shapes and the sizes sequencing tasks under two conditions: first with no handedness restriction and next with a restriction. Under the second condition, movements were made exclusively with their right hands, as a wrapped sweetie was held in their left hands. Another Condition 2 variable was that the materials to be sequenced were placed at the right of the board, spread out and in a mixed-up order. Thus, two problems were avoided: the practical problem of having the felt shapes stick together (potentially causing distraction and frustration with single-handed extractions) and the presumed problem of a midline conflict when the piles were at the centre. Instead, this positioning of the materials induced a rightward, right-handed orientation and predisposed movements that would cross the body midline when objects were placed at the left end of the board at the start of the sequencing. In both conditions, the children were prompted to verbalize before making the placements and when checking the order afterwards.

Each testing session was videotaped, except, by mistake, the one while Eilie was doing the size sequencing task for the first time; the session for the documentary was filmed only by the television crew. The demonstration sets and the pattern continuation sets on which the children had made errors under Condition 1 were repeated under Condition 2. The order of the shapes within the sets was altered (e.g. with the blue-red-yellow stimulus pattern reversed in Condition 2) to minimize a practice effect.

It was hypothesized that the combination of a verbal imprinting (rehearsal and review) with controlled right-hand-only movements would strengthen left-hemispheric processing, reduce motoric competition between the hands and conflict between the hemispheres, and result in improved performance. Although the Preliminary and Main Studies suggested that over time these skills and specializations evolve naturally, it seemed unlikely that improvement could be

demonstrated in trials spaced only days or hours apart, as in this experiment. (The time between the first and second conditions for the Shape Pattern Continuation task was one day; for the Size Progression task, both conditions were presented the third morning, followed by the televising.) Nevertheless, there were improvements under Condition 2.

George made errors in all but one set when he first did the tasks. The correct set was the last of the shape patterns -- the one with all purple shapes, which the Main Study children had also done most successfully. This was also the only set during which George spontaneously vocalized as he made each placement. When re-tested under Condition 2, he again made errors in the second and third repetitions of one set of the shape patterns (the one with the trick shape and variables of colour, shape, and size -- the most difficult set for the other children as well), but, with self-corrections, he completed the demonstration set and the other remaining test set of the shape patterns perfectly. The demonstration paper balls were placed in the same order as before, with the two smallest correct and the others in reversed pairs. In the two test sets of size progressions, he improved when using only his right hand: Then he placed eight objects correctly -- four of the six in each set, versus a total of three previously. (Under Condition 1, the first clown and the first and last dogs were placed correctly; under Condition 2, the errors were reversed pairs -- the position of the fourth and fifth clowns and the last two dogs.) In terms of the percentage of correct responses, George's Condition 2 scores improved by 20% (from 58% to 78%) on the Shape Pattern Continuation task and by 28% (from 28% to 56%, i.e. doubled) on the Size Progression task.

Eilie, the older child by seven months, had made errors in only one set the first times she did the tasks. Instead of repeating the stimulus blue-red-yellow pattern with the last four shapes, she created end pairs of red rectangles and yellow triangles and, with a two-handed midline insertion, an internal pair of blue squares. Thus the pattern was maintained, but with the final repetition in pairs: blue, blue; red, red; yellow, yellow.¹ Using only her right hand, she

¹A similar predilection for matching was shown in Eilie's system of collecting the shapes. She stated her choice: "Got to keep them all in the right piles -- the right colour piles." Likewise, when she collected the paper balls, she made two piles (each with the outer objects put on top of the centre one, from left to right): "These [the three smaller balls] in this pile, and they [the three larger balls] go here." This method of collection was repeated with the three smallest dogs. (With a similar two-part size distinction, George identified the dogs he had arranged as "smallest, smallest, smaller; big, big, big.") Two-part contrasts also appeared in Eilie's speech when she amended her single digressionary comment: "D'you know, one day -- one night, um, Mum -- uh, Dad...", and she said, "I think we better go up", rather than downstairs to return to the nursery. She commented several times about two stuck-together felt shapes.

made no errors in her final placements in this or any other set. Therefore, her Shape Pattern Continuation score of 83% increased to 100% under Condition 2, and her 100% Size Progression score was maintained.

Later, awaiting the televising, when we did a role-reversal with the set of shapes she had matched, Eilie corrected my wrong choices, including a juxtaposition of two red rectangles. During the television filming, while she was doing the size sequencing task under Condition 2, the task was made more difficult by having the objects presented in a pile. Still she made no errors that she did not independently correct (either by replacement and re-selection or insertion).

Developmental progressions suggested in the behaviours of these two children encapsulate, and can serve to summarize, characteristics of the other children studied (and which those who have worked with young children will be able to recognize).

Name writing: George made three figures, the second at the left of the first and the third at the right. Eilie printed her name legibly and from left to right.

Motoric control: Both children alternated feet when walking up and down the stairs. Although the table was low and Eilie was shorter than George (by three and a half inches), she remained seated throughout the testing; George sat while sequencing almost all the objects under Condition 1 (and knelt on, and along, the floor during one entire recitation), but he stood up to place and collect most of the objects when using only his right hand. Thus, George perpetuated a centred orientation to the materials, and crossed his midline less frequently than Eilie.

Under Condition 1, when free to do so, both children used their left hands to obtain some materials, either transferring them to their right hands or placing them directly on the board, the latter incidence with the shapes totalling ten for George and six for Eilie. George consistently pointed to the shapes in the stimulus sets and in the whole series with his left hand, except for the one perfect set when all his points were right-handed (as were his points, and self-corrections, under Condition 2). At first his points did not coincide with his words; later they did exactly.

Under Condition 2, George transferred the sweetie to his right hand twice (during intervals, not during placements); once, undetected, he had put the sweetie on the chair, but kept his left arm at his side while making the placements exclusively with his right hand. (Also once a sweetie was squeezed so that the chocolate oozed through the wrapper and a tissue was substituted.) Eilie did use her left fist to secure some placements, but with no prompts, or accidents, kept the sweeties in that hand. She also spontaneously left spaces between pattern repetitions, and carefully aligned the designs on the balls and the points of the triangles. Her placements

were all in a straight line (including her first upside-down placements of the clowns), but half of George's series (seven of the 13) sloped upwards to the top of the board.

Unlike George, Eilie appeared to refer visually to the stimulus shape patterns while making her placements -- four or five times during each test set, versus George's single visual referral, and during her recitations she kept track of the order visually (even when repeating the "red rectangle, white rectangle, yellow circle" phrases, with repairs), only once tapping shapes in a series with her whole hand in synchrony with her words. (The time she did point, with two fingers together, was to indicate where along the board she would make placements.)

Response to the trick shape: George incorporated the small white circle into his placements both times, with no indication that there was anything odd about it. Eilie exclaimed, "Hey!" and extended it to me, with eye contact, nods, a smile, and an explanation: "A little one."

Self-corrections: George made most corrections after having placed all the shapes, when checking the order by pointing to each shape and repeating the names of the colours (and of the shapes for those that were all purple, calling them 'window, hat, circle' -- the first two suggested when he was silent about naming the square and the rectangle; 'circle' he volunteered with no hesitation, and with a shoulder shimmy). When he came upon an error, he would stop and back-track -- not to the start of the series but to the first of that triplet, until his last correction when he aborted his recitation and reversed the two end shapes in silence. All of Eilie's corrections, of one error in each of five sets during the sessions videotaped, were made spontaneously while she was making her placements.

Both these children gave hints that they were aware of uncorrected errors, hints similar to those of some of the children in the Preliminary and Main Studies. George's was a particular focus in the order of his collections. Both times when he collected the clowns and the first time he collected the dogs, he placed them in one pile -- each time on top of the first incorrect placement in the series, i.e. on the first out-of-order larger object. In his last collection, each dog was put one-by-one into the envelope, from right to left -- starting with the misplaced second longest dog. About her incorrect set, when asked if all the repetitions were the same, Eilie responded, "Yes" and nodded, but kept her eyes lowered.

How these children responded to and avoided errors would have pleased Binet and Simon (1980), who stated, "The avowal of ignorance is a proof of judgment and is always a good indication" (p. 51), in contrast to a child's being "satisfied with his reply when this is obviously and grossly false" (idem, p. 54). George declared, "Oh, can't go any farther. No, I can't -- look!", pointing to a disarray of six shapes.

About another error, he stated, "I need to change some to blue, red, yellow." Other indications of a more intelligent attitude in Binet's (and others') terms were Eilie's ability to attend, search, suspend judgment, and recognize the correct answer -- and (during the role reversal) to show resistance to suggestibility.

Language: From the comments quoted above, it may be seen how George's overt speech influenced his actions (as the experiments reported by Luria [1961] would predict). Whether covert speech, as well as vision, was of assistance to Eilie can only be speculated from her comments and her relatively sophisticated language.² For example, she specified the *length* of the dogs: "It's getting longer, and longer, and longer, and longest!" She not only named the three shapes but also spontaneously added other attributes, e.g. labelling a stimulus trio as "a little green triangle, white circle, blue square". She identified only a few of the shapes out loud while placing them on the board, but, like George, did accompany her actions with verbal commentaries:

George: "I'm looking for a yellow one/the hat/
the smallest one."
Eilie: "Very difficult. Got to find each one
that goes."
"I should do -- I think this one will
go first, because that's the weeest."
"Put that one back."
"I think this one goes after."

Reciting the order of the materials, the children rhythmically indicated divisions between the repetitions: George with pauses and an elongated stress on each third shape named, Eilie with pitch variations, e.g. singing "yellow, red, blue" as a refrain with the notes descending, and accented with 'patschen' (hand slaps on her thighs). Also, her pitch rose as she reported her placements of the clowns: "Little, and bigger, and bigger, and bigger, bigger, and biggerest!"

Conclusion: The examples of how George and Eilie resembled other children in the studies give credence to the possibility that the results obtained with them under Condition 2 could be replicated. Perhaps children who are developmentally about four years old can be conditioned through language and restricted manual movements (possibly also by remaining seated) to improve their performance on these tasks, presumably because the constraints help them to process sequential information more efficiently with their left hemispheres. More than one small experiment with only two

²Recall that according to Conrad (1971), it is generally not until after the age of five that a child will begin to use internal speech in preference to a visual image for recall.

children would be needed to determine whether such conditions could benefit, and be used therapeutically for, children whose left-hemispheric dominance is not yet established -- whether for them also there would be improvements.

REFERENCES

- Binet, A., and Simon, T. (1980) The Development of Intelligence in Children. Nashville (Tenn.): Williams Printing Company.
- Conrad, R. (1971) The chronology of the development of covert speech in children. *Developmental Psychology* 5(3): 398-405.
- Luria, A.R. (1961) The Role of Speech in the Regulation of Normal and Abnormal Behaviour. J. Tizard (Ed.) Oxford: Pergamon Press.

APPENDIX F

FORMS

1. Consent form (sample)
2. Handedness questionnaire to parents
3. Background data on each child
4. Score sheets: Preliminary Study
Main Study
5. School report form: Follow-up Study

Consent form (sample)



UNIVERSITY OF EDINBURGH

Department of Psychology

7 GEORGE SQUARE, EDINBURGH EH8 9JZ

031-667 1011, Ext. 4470

8 June 1987

Dear Parents,

For my postgraduate research, I am studying how deaf and hearing children use their hands, both when performing tasks and when communicating. Your support in having your child participate would be very much appreciated.

For one part of the study, information about right- and left-handedness needs to be considered. To determine parents' handedness, forms are enclosed which you are asked to complete and return to your child's teacher.

As videotapes will be made, it is important to have your consent that they be used

☐ for analysis only☐ for analysis and professional presentation.

You can be assured that complete confidentiality will be observed at all times and that neither you nor your child will be identifiable in any write-up or subsequent discussion of the results.

Thank you very much for your assistance.

Yours sincerely,

Paula Mathieson

Enclosures

Parent's signature

Date

Handedness questionnaire to parents

Mother ☐

Father ☐

2

Do you consider _____ right-handed ☐
 _____ left-handed ☐
 _____ ambidextrous ☐
 (both right- and left-handed) ?

Do you consider yourself right-handed ☐
 _____ left-handed ☐
 _____ ambidextrous ☐ ?

Who (else) in your family do you consider
 left-handed: _____
 ambidextrous: _____ ?

With which hand* do you	L	R
write		
hold a hammer		
hold a toothbrush		
cut with a knife		
eat/stir with a spoon		
strike a match ?		

* + = hand you normally use

Note: If either, indicate with a + for both L and R.

++ = strongly preferred hand

If you write left-handed, is your wrist hooked ☐
 _____ straight ☐ ?

When you clasp your hands, which thumb is upper?

left ☐ right ☐

When you clap your hands, which hand is upper?

left ☐ right ☐

BACKGROUND DATA

Name:

Date of birth:

Age at time of testing:

Hearing status: hearing _____
deaf _____

etiology:

age at onset:

hearing loss: left ear _____dB; right ear _____dB

familial deafness:

communication mode:

Educational experience:

Siblings (age and sex):

Familial handedness (per reports): Mother _____; Father _____

Other information (i.e. bilingualism, ethnic/economic minority status, single-parent family, [other] handicapping conditions):

SCORE SHEET: Preliminary Study

Child:

Date:

					Times
TASK 1: Picture sequences					
Demonstration (apple)	_____	_____	_____		
a. (swing)	_____	_____	_____		_____
b. (door)	_____	_____	_____		_____
c. (kite)	_____	_____	_____		_____

TASK 2: Picture story

TASK 3: Size progressions						
Demonstration (balls)	_____	_____	_____	_____	_____	_____
a. (clowns)	_____	_____	_____	_____	_____	_____
b. (dogs)	_____	_____	_____	_____	_____	_____

TASK 4: Pattern continuations							
Demonstration (RYW)	_____	_____	_____	_____	_____	_____	_____
a. (BRY)	_____	_____	_____	_____	_____	_____	_____
b. (YWB)	_____	_____	_____	_____	_____	_____	_____

TASK 5: Clapping imitations	
Demonstration (l ll)	_____
a. ll l	_____
b. l l l	_____
c. l l l	_____

TASK 6: Movement imitations		
Demonstration:	_____	_____
a.	_____	_____
b.	_____	_____
(c.	_____	_____)

COMMENTS:

SCORE SHEET: Main Study

Child:

Date:

Times

Videotape: _____ from _____ to _____

TASK A: Picture sequences

Demonstration (apple) _____

- | | | | | | |
|--------------|-------|-------|-------|-------|-------|
| 1. (swing) | _____ | _____ | _____ | _____ | _____ |
| 2. (door) | _____ | _____ | _____ | _____ | _____ |
| 3. (kite) | _____ | _____ | _____ | _____ | _____ |
| 4. (bus) | _____ | _____ | _____ | _____ | _____ |
| 5. (balloon) | _____ | _____ | _____ | _____ | _____ |
| 6. (tree) | _____ | _____ | _____ | _____ | _____ |
| <hr/> | | | | | |
| 7. (ball) | _____ | _____ | _____ | _____ | _____ |
| <hr/> | | | | | |
| 8. (cat) | _____ | _____ | _____ | _____ | _____ |

TASK B: Size progressions

Demonstration (balls) _____

- | | | | | | | | |
|-------------|-------|-------|-------|-------|-------|-------|-------|
| 1. (clowns) | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| 2. (dogs) | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

TASK C: Pattern continuations

Demonstration (RYW) _____

- | | | | | | | | | |
|----------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1. (BRY) | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| 2. (GWB) | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |
| 3. (stc) | _____ | _____ | _____ | _____ | _____ | _____ | _____ | _____ |

Comments:

School report form: Follow-up Study

5

Child: _____
 Date of testing: _____
 School attended when tested: _____

Please circle the word which most accurately describes the child's present performance, relative to the other children in the classroom (or indicate your rating along/beyond the continuum), and add any information you consider relevant.

CLASSROOM GROUPING

General:	high	middle	low
Reading:	high	middle	low
Maths:	high	middle	low

SPEECH/SIGNING SKILLS

Comprehension:	good-----satisfactory-----poor
Intelligibility:	good-----adequate-----poor
Impediments:	none lisp stutter other:

WRITING SKILLS

Handwriting:	good-----average-----poor
Hand used:	right left

PHYSICAL COORDINATION

Fine motor skills:	good-----average-----poor
Gross motor skills:	good-----average-----poor

VISION

Eyeglasses worn for near/distant correction:	yes no
Squint:	present absent

GENERAL

Activity level:	high-----average-----low
Behaviour:	appropriate inappropriate
Sociability:	solitary-----sociable
Communications with peers:	frequent-----occasional-----seldom

ADDITIONAL COMMENTS (continue on overleaf if you wish)

APPENDIX G

MAIN STUDY EXAMPLES: DESCRIPTIONS OF SIX GIRLS

Three hearing and three deaf girls were considered archetypes for certain handedness patterns that recurred in the ways the children in the studies manipulated the task materials. How these three dyads compare with other hearing-deaf dyads is discussed in Chapter 6; samples of their language are included in Chapter 7. The intent of this appendix is to portray their actions, within the context of what they said and signed, and so to interpret what some of the numbers in the analyses mean.

All six girls were classified as right-handed. The three who are hearing were in the same nursery school. Two who are deaf were in total communication classes at one school, and the other deaf girl was in the oral class at another school. At the time of testing, they were from three-and-a-half to seven years old (i.e. six months from the youngest and the oldest children in the Main Study). Five of the girls, however, are among the younger children in the study, and differ in age by only eight months. Another similarity of five is that their total scores on the sequencing tasks are below the mean for all the children tested in the Main Study. In spite of these similarities, there are differences...

Together, these six girls demonstrate characteristics of three basic contrasting systems seen in the manual actions of all the children. They can be represented as three stages of development.¹ The three stages are outlined (on the next page) to show some general distinctions of the handedness patterns -- which hand was used, where the materials were placed and how they were collected.

¹As with other systems of classification, this differentiation may give a false impression of exclusivity -- or necessity. (See Piaget [1959] regarding acknowledgment of the arbitrariness of classifications and individual overlapping residuals in stage progressions, and Erikson [1977] about relative accelerations and retardations within stages.)

STAGE 1	STAGE 2	STAGE 3
<i>Placements</i>		
symmetrical	asymmetrical	asymmetrical
centred	2-part/paired	serial: linear
bimanual	unimanual	right-handed
<-----m----->	<-----m-----/	-----m----->
centring body	.....	arm extensions and
shifts	.....	midline crosses
no insertions	.....	insertions
no changes	.....	self-corrections
upside-down/	.....	righted
sideways	.....
no s-set refs	some s-set refs	many s-set refs
<i>Collections</i>		
one-by-one	.....	cumulative
bimanual	unimanual	left-handed
----->m-----/	<-----vvvvv----->	-----m----->/
<-----m----->	.....	<----->
by attribute	.....	sequential

m = midline of child's body
s = stimulus
v = varied/alternating

Amelia and Jessica represent a primary stage: identifying similarities and arranging materials symmetrically, and using both hands simultaneously. Lucy and Simone typify a Stage 2 system: relating isolated parts to each other while ignoring whole patterns, and using their right hands predominantly. Polly and Alice represent the highest order (Stage 3) system: relating all parts to the whole in a continuous progression, and coordinating both hands. The six girls are described in this stage order, beginning with the hearing exemplars.

HEARING CHILDREN EXEMPLARS

Amelia. When tested, Amelia was three years and seven months old (the ninth youngest child in the Main Study) and was the only child in her family. Maternal ambidexterity was reported: for her mother, her mother's father and grandfather. Amelia's total score of 25% (50% on Task A, 25% on Task B, and 0% on Task C) is the fifth lowest of the Main Study children; her age-adjusted score is -4, so she ranks 39th among all the children and 31st among the 40 hearing children.

Amelia's Inventory Handedness Ratio is .467, the furthest left within Band 2. Doing the Inventory activities, she showed consistently symmetrical preferences. Her exceptional style of throwing the ball was from her chest, with both hands (and it was the position she reverted to after two elicited throws with her right hand, followed by initial left-hand failures). She clapped her hands with an equal central contact, clasped her hands with her fingers intertwined but with both thumbs up, and folded her arms with both arms parallel. For both footedness and eyedness, her ratios were zero (as were those of only two other children): She kicked the ball spontaneously with her right foot but could hop only on her left foot; she looked through the eyepiece of the video camera first with her right eye, then left eye, then right eye again, and indicated she could not see through the kaleidoscope hole with either eye.

Amelia's handedness ratios on Tasks A-C have a range of .213, the narrowest but for four other children, and a mean of .467. Thus, her Task and her Inventory Handedness Ratios are identical -- the sole incidence of equivalence among all the children. Her Task A score of 50% is at the mean for the hearing children and just above the 46.3% mean for all the children. As this is her highest score, she is one of the minority of eight (all younger) children whose highest untied score is on Task A; she is again in the minority of the two of them whose total and age-adjusted scores are below the means. Also, of the 14 hearing children who have all positive mean ratios for Placements, Assists, and Collections on both Tasks B and C, she is the only one who has a below-mean score on both tasks. (The combinations of her positive and negative ratios on the sets of Tasks A-C are reported in Chapter 6.)

The following report of Amelia's movements is comprehensive: Through the accumulation of details, the essence of her particular style is documented.

As with the Inventory activities, the distinguishing feature of Amelia's handedness patterns while doing the sequencing tasks is symmetry. Most striking is her system of changing the order of the picture cards -- with both hands crossing, simultaneously exchanging two cards. These changes were made only after the cards had been placed, all one-by-one on the board as each was looked at, all left-to-right, and all except the two-card sets in the given order. As she looked at the cards, she righted them, rotating them with both hands. When one card was placed on the board before she detected the position error, she said, "Nah -- that's upside-down" and giggled as she corrected it. (Also noting "It's upside down", she re-adjusted a triangle.) In most instances, she 'read' the cards as she held them, sing-songing her descriptions -- with many words unintelligible, as her speech had consonant substitutions, was quiet and slurred, and her mouth was often obscured by the card she was holding.

An example of Amelia's two-hand two-card exchanges is the first swing set.² From the initial placement of 3 --> 1 --> 2, the two cards reversed were

- a) 2 and 1 at the right and middle (--> 3 2 1),
- b) 2 and 3 at the middle and left (--> 2 3 1),
- c) 3 and 1 and the middle and right (--> 2 1 3),

²The following are the notations used throughout the transcriptions. 1) The numbers in regular type indicate the correct order of objects: '1' of the picture-card sets is the first event of the series; of the circus cutouts, it is the smallest/shortest object. 2) The numbers in italic type, with hyphens, indicate *ordinal movements*: the first to the last objects placed or collected. 3) Spaces between objects are marked with dots (...). 4) The child's midline is indicated with an underscoring (). 5) Alternative interpretations of quotations are recorded within brackets ([]).

d) 1 and 2 at the middle and left (--> 1 2 3).

Thus, four two-by-two exchanges were made until the sequence was correct, whereas one simple replacement (of the card at the left to the right) would have sufficed. Her system of using both hands simultaneously avoided insertions and maintained a central symmetry: Each time the middle card was one exchanged. Her final arrangements were sealed with simultaneous and parallel movements: contacting the card at the left with her left hand and the card at the right with her right hand; lifting both hands up and then placing them in her lap.

In the above exchanges, all crosses but c) were made with her right arm the upper -- her preference throughout: 13 of her 15 crosses in the eight sets of Task A were made in this position. Also, in all the three- to five-card sets, the first exchanges were of the two cards at the right; in both the four- and five-card sets, the next exchange was of the two adjacent cards at the left, also left of her midline. Only in these two longer sets and in set 2 was a one-handed change made -- the final movement of a card to the far left position, slid over the other card(s) with her right hand. What is remarkable about the final order of the last two sets is that the three cards to the left of and at her midline were in a consecutive left-to-right order, although not also sequential in set 8:

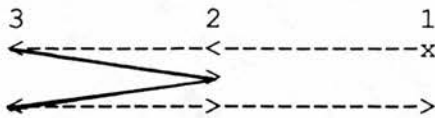
2 3 4 1 in set 7;
2 3 5 1 4 in set 8.

Another centre-supremacy was shown in Amelia's description of this swing set: begun, continued, and concluded with the middle card (#2, that depicting the critical action, the fall from the swing). Her staccato speech was punctuated with right index-finger taps at each card. The pattern and narrative follow (with the words underscored when coincidental with taps):

1	2	3	2	" <u>Fell</u>
	x----->		3	<u>off</u> . <u>Mommy</u> . <u>It better</u> .
<-----			2	<u>Dead</u> .
			1	<u>Boy on what</u> is it? -- the box. ³
			2	<u>Then</u> <u>fallen</u> away."

A right-left alternate weaving with a centre concentration was again displayed in Amelia's description of the next set, which began and ended with card #1, moving leftward first, in the correct sequence, and finally rightward, after an interim middle detour:

³Amelia's mistaken identification of the girl as a boy and her having another name for the swing are among the common errors reported in Chapter 7.



1 "You
 2 paint with .
 3 the door,
 2 going
 3 over
 2 all of
 1 the door."

Amelia's back-forth movement was complemented in a gesture during her subsequent comments about her daddy's painting a door: Her words "open or shut or open or [?]" were accompanied with right-hand waves.

As the reproductions of the cards in Appendix A show, a visual symmetry was provided by the centre placement of the #2 card in this set and of the #1 card in the next set (the boy with the kite) -- the only three-card set that was not not in a sequential left-to-right or right-to-left order. The two times a card was dropped, it had been held at her midline (a not uncommon phenomenon). During this and the other tasks, some body movements were shimmies when her hands were on the table and rocks when her hands were on the chair.

A further method of left-right balancing, i.e. central stabilization, is seen in Amelia's counterpoised collections of the cards. In the demonstration set, both two-card sets, and set 7 -- the sets with descriptions simultaneous with placements -- the left-to-right placements were followed directly with *right-to-left* collections. In set 3 after her left-to-right placements, her *descriptions* were right-to-left, and then her collections were from the middle to the left and then to the right. (Also, when misunderstanding the request to collect the cards in the demonstration set, Amelia imitated the points of the examiner in the reverse direction.) Before replacing each of the cards one-by-one into the box (her style of collecting the cards in the demonstration and eight test sets), she moved the box nearer to herself alternately with each hand until the last time when she moved the box with both hands at once. In that last set, of five cards, she removed the middle card first, with both hands, then moved outward for the two at the left and outward again for the last two at the right. (The three right-handed removals were followed by a left-hand contact with the box and vice versa for the far left left-handed removal.) This ultimate equivalence, seen in her collections of the cards in the other sets as well, persisted.

As all 28 picture cards were placed on the board from left to right, so were all 28 shapes -- the nine in each of the three sets plus the 'trick' shape. (Although she said, "Here's a wee one" and giggled about the small white circle trick, she placed it along with the others in the given order.) Only one shape was not placed with her right hand (the first in the last set). Collections, however, were again in the opposite direction: In set 1, all but the middle shape, removed first, were collected from the right to the left, and cumulatively (i.e. with one hand gathering up each shape in the line, rather than transferring each to the other hand or to a pile).

The last nine shapes of set 2 and all 12 in set 3 were also collected in a right-to-left direction. (The first two shapes collected in set 2 were identical white circles; the next two, different, shapes were put inside them, and then all the others on top. Pointing to this pile, with a right and left index finger, Amelia commented, "I think it's a sandwich.")

In how Amelia used her hands to collect the shapes there were other symmetries. The only shapes collected with both hands at once were at her midline: the white circle 'trick' shape of set 2 and the triangle she had righted in set 3. Of the other 12 shapes in set 2, half were collected with each hand. In set 1 only the last two shapes at the left were collected with her left hand, as were the second and last eight in set 3. When she held the pile in her right hand, all but one were put under the other shapes -- the opposite of the two put on top with her right hand when the pile was held in her left hand. (The exception was the last, also put on top, as a sort of end parenthesis.

A similar bracketing was created in the next task by Amelia's final simultaneous left-hand placement at the left and right-hand placement at the right of the demonstration balls #5 and #6, thus enclosing the four smaller balls. (Only with resistance, i.e. hesitating, pressing the #6 ball, and shaking her head, did she insert the #5 ball into the space provided.) In the test sets, the smallest were again embedded, in a 4 2 1 3 6 5 --> 4 1 3 6 5 2 order for the clowns and a 6 5 1 4 3 2 order for the dogs. (Muttering "That's the daddy one. ... Where's the wee one? ... Here's the tiny one -- umm hmm!", Amelia selected from the envelope the smallest three clowns for her first placements, the largest three for her last placements.)

Two contrasting symmetries were achieved with the clown placements: 1) The *smallest* clown was in the centre position in her first three placements of the three smallest clowns, and remained central with her next two encircling placements. 2) With the last addition of the #5 clown, adjacent to #6, and a temporary placement of the #2 clown at the far right, but *with its gap kept*, the *largest* clown, at Amelia's midline, was now in the centre position: 4 ... 1 3 6 5 2 (i.e., between *descending* clowns, and again with the larger of the enveloping pairs to the right). The largest and smallest clowns received other attention: a) A left middle-finger contact with the biggest, midline, clown was made in a surreptitious manner (with a quick movement, a coy smile, and a look toward the examiner while the order of her placements was being recorded). b) When asked if the clowns were in the order of *littlest* to *biggest*, Amelia moved (again) her left middle finger down along #6 saying, "This is a big one" (and repeated the movement with her *right* middle finger on #5 adding, "And this is a big one"); next she declared, "And this is a tiny one", with both hands inspecting the front and back of #1; then she returned to #6, adjusting its placement with both hands. c) For the collection, a serial order was begun but was aborted; instead, opposites were paired, from the most to

the least extreme. With a right-left waver over #2 and #1, #1 was put on top of #2; but then (with a head wag and "Nah, he goes after his daddy"), it was put on #6 -- i.e. the smallest on the largest at her midline. Completing her 'family', she put #2 on #5 (saying, "And he goes after his mummy") and with these held together with both hands, the middle pair (#3 and #4) was picked up last.

In her placement of the dogs, Amelia's movements were in an outward vortex, from the smallest placed first (in the centre) to the largest placed last (at the far left): 6-2-1-3-4-5. Their collection was cumulative, from right to left with her right hand with the exception of #1 -- the only error in what was a *right-to-left* smallest-to-largest sequence: 6 5 1 4 3 2. That one was removed from the middle with her left hand and placed on #2, so that her collection was in a perfect progression: the smallest through the largest dogs (versus the eddy of the smallest with the largest clowns).

Amelia's counterbalancing of rightward Placements with leftward Collections in the other two tasks was also her pattern in this size progression task, again with corresponding handedness patterns: Of the clowns, all but the far left one were placed from left to right, all with her right hand (while she held the envelope with her left hand); all were collected from right to left in their oppositional pairs, with both hands. Of the dogs, all but the two at the far left (the two largest, again adjacent, but now the left-most pair) were placed in a left-to-right order, only two not with her right hand (the last, and largest, at the far left of the set and the one, #3, just right of her midline -- a position that was differential for other children as well); all but the smallest one were collected from right to left and all but that one with her right hand. Thus, most placements and collections of the objects in the dominant direction were with her right hand; those violating the direction were with her left hand.

Although Amelia was credited with only three correct Task B board placements, she demonstrated a comprehension of both sequential and spiral orderings, and a complementary use of her right and her left hand. Her relative success on Task A could be associated with her sense of symmetry, a totality of perception, and with a sort of directional control.

Lucy. Lucy is the hearing girl who contrasts the most to both Amelia and Polly -- and is characterized by contrasts. In her family, she is the third and youngest child; all are reported to be right-handed, and to speak English at home. (Her mother is Scottish and her father is Chinese.)

Lucy's total score of 17.7% (20% on Task A, 33% on Task B, and 0% Task C) is the lowest of these six girls and is the third lowest of all the children (higher than only the two youngest children in the study). Her age-adjusted score (-26) also is the third lowest, the very lowest of the hearing children.

Of the six girls, Lucy's Task Handedness Ratio of .499 is the most rightward. Her Inventory Handedness Ratio (.692) is the furthest *right* ratio (versus Amelia's furthest *left* ratio) within Band 2. Her Inventory footedness ratio of .333 and eyedness ratio of zero indicate mixed preferences. For instance, she hopped equally well on each foot and walked down flights of stairs alternately leading with her left foot and right foot. Intermittent strabismus and unstable focalization (saccadic eye movements) were noted during the testing.

In what Lucy both said and did there were repetitions of similar patterns. In both, opposites were prevalent. A first comment, before accepting assistance to write her name, was, "I can only draw a man. ... When I'm a bit bigger -- I'm little, 'though, and I can't draw numbers." Such 'can/can't' and 'big/little' contrasts (and the substitutions, of 'draw' for 'write' and 'numbers' for 'letters') are typical of her language. About the first task set of pictures, Lucy's categorization concept was explicit as she declared, "Not the same as that one. The same as that one." The deictic 'that one' and other comments about 'one' and 'ones' have an analogy in the one-by-one pattern of her commenting on a picture as it was turned over and of continuing to isolate each picture in her (elicited) descriptions of the series, as well as in her one-by-one board-to-envelope collections.

As in her verbal classifications, also in her manual distributions of the materials (with her right hand dominant), polarities were expressed. In her placements of the clown cutouts, the three littlest were at the left, the three biggest at the right, with a space in between: 3 2 1 ... 4 6 5. The first placed, at her midline, was the smallest. The next three were placed progressively further to the right, and the last two to the left -- again outwards from the centre: 6-5-1-2-3-4. As Lucy placed the clowns, she labelled each: "It's a tiny one! A nice tiny one", adding "I like tiny one[s]", and later identified this first, smallest, centre one as "Lucy". About the three largest ones, she said, "A big one -- it's the mummy"; "The big one is the m--, the daddy"; "And that -- that's Nanna", and about the other smallest ones said, "Another little one -- that's Barbara. And this is -- Robert" (correctly naming the larger as her elder sister, and the other as her elder brother). She later rechristened them all except for the largest, "Daddy", and the smallest, herself, but she kept the three largest -- her parents and grandparents -- at the right, the three children at the left.

Except for these references to her relatives, there was little indication of relative concepts: There was neither differentiation *within* these dichotomous groupings nor in her speech, as most adjectives were not inflected for the comparative or superlative. However, when she put the clowns back into the envelope, one-by-one, and with a song accompaniment, they were in a perfect sequential order, from the biggest to the littlest. (She had removed the #3 clown after the #2 clown, but correctly inserted it behind the

smaller one.)⁴ Such an ability to detect size gradations demonstrated when nesting materials in a central, vertical position yet without application to extended, horizontal board placements was not exceptional. Nor was her variation of two-part groupings, described next.

Instead of the two groupings of the six clowns, the six dog cutouts were placed on the board in pairs: 2 1 / 5 6 / 3 4. The first was again placed at her midline, the next two at each side of it, then two simultaneously at the right and the last at the far left: 6-2-1-3-4-5 left. (This closure movement was often chosen by the children, with observance of centre-out and no-insertion rules.) The dogs were given nominals (e.g. "Poppa dog", "the daddy dog") -- but with no pronominal referents. Placements of the dogs back into the envelope maintained the pair associations (with reversals so the sequence alternated in a total up-down-up pattern): 1 2 / 6 5 / 3 4.

Lucy's procedure for placing the shapes was in a left-to-right order except for the fifth shape in one set (placed at the far right end of the board) and the seventh in another (a small green triangle, inserted at her midline between two large white circles). All were placed with her right hand, each extracted from the pile on the board or held in her left hand. Some shapes were matched: Red, yellow, and green shapes were placed together in pairs (with blue squares symmetrically encompassing the red and yellow pairs); all the large white circles were placed together in front of her; all the white and all the purple circles ("flat ones") were collected first (the first two purple circles simultaneously with her left and right hands parallel, the whites again in a middle-first 5-2-1-3-4 order). About the remaining shapes in set 2, Lucy commented, "Lotsa little ones." (Lucy did the tasks in an A-C-B order so this comment, as the one about writing her name, was made before the cutouts were to be sequenced by size.) Lucy's collections of the three sets followed a back-and-forth order, with only five last shapes in one set collected consecutively to the left and four last shapes in another consecutively to the right. Her one-by-one board-to-envelope collections of 33 of the 37 shapes were made with her right hand only; in the last set of all purple shapes, two circles were collected simultaneously with both hands and the left-most two shapes were collected with her left hand and then transferred to her right hand. The role of

⁴The order of Lucy's removal of the clowns from the board was 5-4-6-3-1-2: The centre object within the large and small groupings was selected first and the others were removed in an inward direction (versus the outward direction for the placements). Those to the right she collected with her right hand, those to the left with her left hand. All were inserted into the envelope with her right hand -- directly for those removed from the board with her right hand, but with left-to-right-hand transfers for the other three.

her left hand was to adjust the opening of the envelope positioned on the board. Thus, all Lucy's placements and 89% of her collections of the shapes were exclusively right-handed, and her collections were one-by-one rather than cumulative.

How deliberate or how accidental Lucy's colour matchings were can only be speculated. She did place the 'trick' shape, the small white circle, apart from the three centre white circles, at the far right. This segregation and her placement pattern of the all-purple shapes (by three's with each a different shape, but none in the square-triangle-circle order of the stimulus set) suggest a perception of 'difference'. But her Task C procedures may have simply been expedient: She made no visual references to the stimulus sets and no changes to the original placements of the shapes -- or of the circus objects or picture cards. Also, each placement in the demonstration set had been prompted (regarding continuous horizontal placements as well as the colours/shapes selected). During a collection, she spoke at length about a penguin video programme, and to her "Stuff! Stuff! Stuff!" comment about an envelope full of shapes, she added that "Barbara gives some -- too much -- food to the cat." However, her whispers while she placed shapes were appropriate: e.g., "One, there; one over there; ...a little one, like this, and a blue like this; ...this one there."

Throughout the testing, Lucy would stand (only during three picture sets did she remain seated) -- so she was constantly centring herself with the materials. Likewise, the cards of all the picture sets were placed symmetrically from her body midline.

Lucy's disregard for the sequential ordering of the materials and her rightward bias were reflected in her variable patterns of placing and removing the picture cards. Four of the six test sets were placed from right to left, one from left to right, and one two-part set simultaneously at the left and right. Of her collections, two were from left to right and two were simultaneous; one was from right to left and one was from the middle to the left then to the right. While in each set each hand was used to place the cards, in three of the sets her right hand was used exclusively to collect them.

Another order was violated in Lucy's placement of the three picture cards in the first set -- all sideways, so that her description of the girl having fallen off the swing was "...that one's running." (When an ordering of the righted cards was prompted, she began an up-down rather than a horizontal placement.) Also, contrary to the vertical placement of the red rectangle in the demonstration stimulus set, all her placements of the red rectangles were horizontal, and when a white rectangle had been adjusted to the vertical position by the examiner, she replaced it horizontally.

Some of Lucy's speech has been quoted because it seems to relate to her approach to the tasks. Also, it contrasts to

Polly's silence.

Polly. Although Polly was only four years and three months old when tested (one month younger than the mean age of all the children, two months older than Lucy and eight months older than Amelia), she scored 100% on each of the three tasks (including all eight sets of Task A). Like Lucy, all her relatives are reported to be right-handed. Unlike Lucy, she has only a younger brother.

Polly's Inventory ratio for handedness is .231, within Band 1; it reflects some left-hand preference (as does her Task Handedness Ratio of .024). For instance, she began her drawing with her left hand. Her footedness ratio was (an unusual) -1, and her eyedness ratio was (the prevalent) +1.

Polly exemplifies a manual system of consistent variation -- a pattern associated with sequencing task success. The way she used her hands when performing the tasks showed coordination and deliberation. For example, every time after she had sequenced a set of the picture cards, her hands oscillated over the cards at the left and at the right, but each tentative first collection of the card at the left was arrested, so all her collections were from right to left. The cards were put one-by-one into the box, always with the picture-side up. (In the first and third sets the cards at the right and middle were put into the box with her right hand, the card at the left with her left hand; in all other sets, they were put in with the same hand -- her right for four, her left for the sixth and last sets.)

Polly's simultaneous two-handed approach to the collections of the picture cards shows her penchant for symmetrical movements. Other symmetries displayed also in that first task occurred while she was describing the events: She would point to the cards at the left of her midline with her left index finger and to those at the right with her right index finger, and she used parallel *connected* constructions in her speech, e.g. "That's the balloon and that's the needle." In her second task, she placed the first three clown and dog cutouts at the left with her left hand, then the other three to the right of them with her right hand, except for one at her midline that she placed with both hands together. Other symmetrical, and syncopated, motions were jiggles, kicks, and tongue clicks. Her name writing also showed a symmetrical centring (as well as an aggrandizement): For the 'L', her first stroke was the horizontal line drawn from right to left, towards herself; then the vertical line was drawn, detached, away from herself. For the 'Y', again the first stroke, the vertical, was towards herself; the final strokes of the left then the right diagonals were, with repairs, again drawn away from herself.

Most significant was Polly's control of her symmetrical movements. Often she suppressed all but shadow -- poised, complementary -- positionings of her inactive hand. Her placements, and adjustments, of all the materials were

precise, almost pernickety. Also, her lateralized system of collections continued, so that up to the last two, very large, clowns (that were amassed with both hands), all were collected with her left hand, as were all six of the dogs in the next set, and always from left to right. In her last task, not only were all 36 shapes collected with her left hand, but also all the shapes but one were placed with her right hand. (It was the fifth of the nine shapes of the first test set, a large white circle, which was the one and only shape she placed with her left hand -- at her midline.) The deliberation of these manoeuvres was in spite of their difficulty: The collections were not one-by-one, as with the picture cards, but were cumulative, each smaller clown and dog cutout put on top of the next larger and transferred on, each of the twelve felt shapes in each set grasped with no right-hand assists, and with midline crosses. Interruptions to push her hair back, to rub her nose, scratch her back, and adjust the nursery dress-up necklace and Batman cape did not deter her.

Another indication of Polly's exercise of control was her refraining from extraneous comments, although she amply and spontaneously described the events in the pictures. After the "...what's happening?" request about the first picture set, all other descriptions were offered spontaneously at the completion of her placements, and the collections were prompted for only the first two sets. Furthermore, for all but one set, she first displayed all the pictures on the table at the edge of the board, scrutinized them in silence, and only then placed on the board. (When she did retell the events in that one set, her repeated descriptions were almost exactly the same as before, but then the events were reported sequentially, so that recitation also was completely correct.) For only the last two longer sets, her narratives were simultaneous with the board placements. In response to questions about the instructions (e.g. "Do you know what to do?"), Polly would nod her head or would point to the pictures, replying, "First one, next ... last". Exceptionally, she spontaneously extended one description beyond the events depicted in the three cards: As she pretended to pinch the stuck kite from the tree in the picture, she added, "They can get it down, like that."

That Polly's systems were of her own devising can be surmised from the ways her movements differed from the verbal suggestion and the actual example of the examiner. The request with the demonstration set of the picture sequences had been to pick up the cards from the one at her left to the one at her right (said while each card was pointed to). However, perhaps since the top card in the box from that set was the first of the sequence, her glance at it could explain her wavering and determining the opposite, right-to-left, one-by-one collection of the cards in the first test set and that same directional order in the rest of the sets. With the collection of the shapes, she followed the left-to-right order demonstrated with the sample set, but instead of creating four piles of the three shapes comprising the pattern, she

continued each collection non-stop from the first through the last shape. (Polly's specialized system was to place all but one of the 37 shapes with her right hand and to collect them all with her left hand, with no right-hand assists.) A last continuity to be mentioned is that Polly opted to continue the testing: When two tasks had been completed and it was suggested that it was story time in the nursery, she responded, "Not, not quite next."

Throughout the testing, Polly maintained an interim attentional posture of having her elbows equidistant on the table with her hands semi-circling the sides of her face, or of having both hands in her lap. In the following drawing this position of hers is compared to the typical postures of the other two hearing girls.

DEAF CHILDREN COUNTERPARTS

Jessica, vis-a-vis Amelia. Among the many similarities of these two girls are their ages, their scores, and their Inventory Handedness Ratios. When they were tested, Jessica was just three months older than Amelia; her total score on the sequencing tasks is 2.3% higher, and her IHR is but .033 more rightward. (Jessica's age-adjusted score is above the mean for the deaf children, whereas Amelia's is below the mean for the hearing children.) Jessica's three Inventory ratios have means that reflect an opposition with synthesis that is basic to her style: The mean of the 11 manual actions is .500, the same as the mean of her foot ratio of zero and her eye ratio of +1.

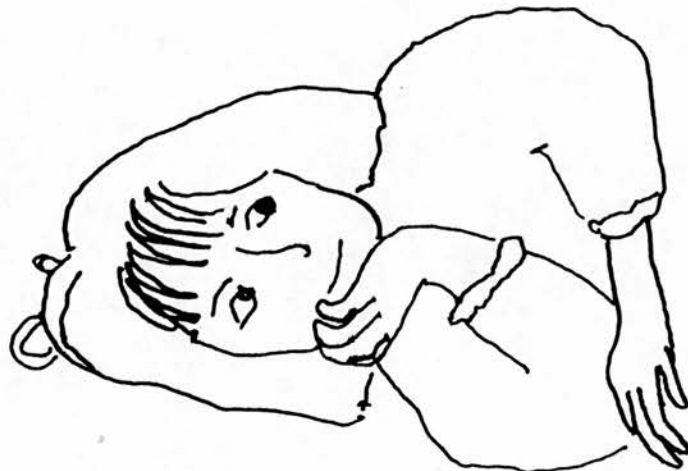
Jessica is the middle child in her family: She has an older brother and a younger sister. They and her parents are also deaf. Her hearing loss is reported to be between severe and profound. As for Amelia, maternal-lineage ambidexterity was reported for Jessica: for her mother's two sisters.

Jessica's Task Handedness Ratio of .092 indicates equivalence in the use of her right and left hands while she was doing the sequencing tasks. (It is .375 more leftward than Amelia's and, except for Polly's, is the most leftward of the six girls.) Examples of ambidexterity in Jessica's handedness are indicated in several of the tables in Chapter 6 and include the following:

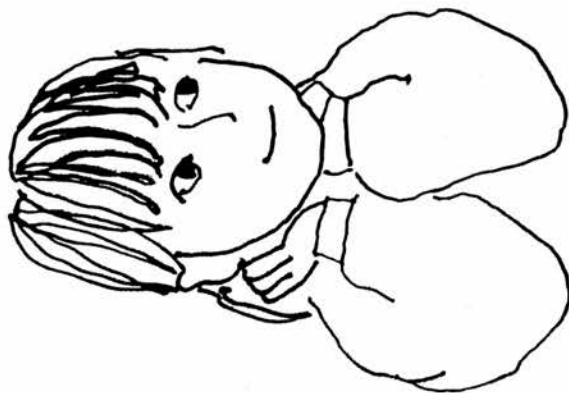
- Of the six girls, Jessica has the fewest absolute ratios but the greatest number of negative ratios. (Only she and Polly have a negative mean task ratio -- Jessica on one task, Polly on two tasks.)
- Both Jessica and Amelia transferred the majority and a nearly equal number of materials to their right hands (30 and 29, respectively), but -- consistent with the negative ratio proportions -- Jessica made three-times more transfers to her left hand (18 for her versus six for Amelia).
- Jessica's single midline cross during the test sets was



Polly



Lucy



Amelia

with her left hand, and in her one simultaneous exchange, her left hand crossed over her right hand (the opposite of Amelia's right-hand-over pattern).

- In the duration of contacts with the materials, Jessica is the only one of the six girls who had longer left-hand than right-hand contacts. (Her left-hand percentage is twice that of her right hand -- a proportion surpassed only by ambidextrous Joel and left-handed Samuel among the 20 children in the sample.) Of all 20 children in that sample, Jessica has the greatest proportion of two-handed durations (89% on Tasks A through C, 87% on Task A alone).

During the testing, Jessica, like Amelia, was loquacious (Amelia when speaking, Jessica when signing and speaking). Although their narratives were more related to the task materials than were Lucy's tangential stories, their verbal and manual enunciations lacked her precision. Substitutions and elisions of phonemes in Amelia's speech have a counterpart in the chereme variations in Jessica's signs.⁵

For example, 'different' (the sign Jessica repeated the most often) was sometimes signed conventionally, with both index fingers, but at other times, in conjunction with other signs, it was signed with her index and middle fingers of both hands (an ASL 'U' handshape). Thus, in her "Fall -- different" statements, a sign rhyme 'allocheme' was created. Also in her commentary of that picture set, she made a semantic elision by maintaining that closed two-finger handshape in her combined 'swing-fall' sign, and later in a 'tree-fall' mime.⁶ Another composite sign invention was 'paint-door': First she had signed 'paint' plus 'door' in a segmented sequence, using the standard two-finger sign for 'paint'; later in the composite sign, 'paint' became an sign alliteration when it was changed to match the open handshape of 'door'. Her conclusion, "Finish!" also was a sign amalgam: Its beginning handshape incorporated the position of 'door' with the movement of 'paint', so with the three parameters of a sign, it created a complete synopsis.

Like the double-finger 'different', 'blue' (but not its component in the compound 'red-blue' for 'purple') was signed not with one finger, as in the sign of other children at her school (including her brother), but again with those same two 'U' fingers. 'Last' was once signed with her right index,

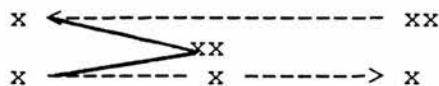
⁵As a minimal component of a sign, a chereme is analogous to an oral language phoneme (Stokoe, Casterline, and Croneberg 1965).

⁶In these transcriptions, a hyphen between the words means that the two words were signed simultaneously, one hand signing one word, the other hand signing the other word. Otherwise when words are hyphenated, e.g. 'both-of-them' and 'all-of-you', this means that all the words were expressed in one sign.

rather than little, finger striking her left little finger -- a formation retention of the sign she had just imitated: 'first'. (There was possibly also a confusion of their meanings, suggested just previously by her saying 'last' while signing 'first' -- unless her accompanying headshake compounded an implied contradiction, i.e. "Not last -- first".) Another retention involved a transfer: After signing 'second' with her right hand, she repeated 'second', but with her left hand, while simultaneously signing 'third' with her right hand. (Again there is an ambiguity: Had there been an ellipsis, "second then third", or "That's second and that's third" could have been intended.)

Other alterations of Jessica's (and Alice's) signs were signing with either her right or left hand, with one hand or with both hands; speaking while signing or only signing or only speaking (or mouthing) words; dislocating signs (e.g. signing 'forget' at her forehead or at her shoulder or chest, and both 'think' and 'finish' at her mouth); and inverting positions (e.g. imitating 'help' with her left, rather than right, hand underneath; 'new' with her active hand inside, rather than outside, her other hand; and 'thing' with fists out, then reversed to match the examiner's fists-in sign).⁷ These expressive actions are mentioned outwith the Language chapter because they relate to Jessica's other handedness patterns.

Handedness and directional impartiality was shown also in Jessica's placements of the materials. In a repetition of the demonstration set and in the six test sets, all Jessica's initial placements of the picture cards were with the #1 card of the correct sequence in the right-most position, whether it was the first, second, or third card placed (e.g., first in one two-card set, second in the other). The centre card of one set was at her midline; in all other sets, one card was at the left and one at the right of her midline, with the other in the three-card sets further to the right. Other discriminations of this far-right card in one set were that its placement involved Jessica's single, left-handed, cross; that a space was kept between it and the other cards; and that a "Good, good; *different*" verbalization was added. (All the cards in the other test sets were deemed 'different', once in an Amelia-like zig-zag pattern, shown below with 'x' indicating the position of the cards for the eight, single or double, iterations:



⁷Alice similarly inverted 'old', moving her finger back rather than forwards. Another similarity is Amelia's having imitated points in the reverse direction.

The first were signed while Jessica placed the cards; the last three were a summation.)

Twice in the demonstration set the middle card was placed *first*, and in all but one of the three-card test sets the middle card was placed *last*, as above. The last four sets were in the correct sequential order, but in a (right-to-left) direction. Although these placements were reversed, Jessica's concluding *descriptions* of the events depicted in three sets were in the correct order, and she spontaneously corrected the order of the cards in one set. (Previous comments had been simultaneous with placements -- as were those of other lower-scoring and younger children.)

Also, like all the others but Lucy, Jessica made frequent simultaneous, symmetric two-handed contacts with the cards and other materials on the board. For example, collecting the three-card sets, she first simultaneously contacted the card at the left and the card furthest to the right, adding the inner-right card with her right hand, then placing the pair under the card in her left hand to complete the collection. (The two cards of the other two sets were collected simultaneously, but with the right cards over the left cards.) hand.

Like Amelia, Jessica arranged the circus cutouts in pairs, and with midline primacy awarded to the largest objects. However, Jessica did not adhere to a linear placement of the clowns. Initial placements were alternate, resulting in two smaller clowns to the left of her midline and two larger clowns to the right (the smaller of each group in the upper position); all four were placed horizontally, with the feet towards the centre. Next, the largest clown, was dropped further to the right, in a vertical position:

1		4	
3	—	5	6

With her first re-arrangements, all placements were horizontal; the #2 clown was now included in the preserved top-down size sequences, and the #4 clown was excluded:

1			
2		4	5
3	—		6

Labellings during these placements were 'baby' and 'small' for the smallest clowns (the rocking and measuring movements of the signs made while they were held) and 'big -- both-of-you' for the largest two. "Baby", "sister/girl" and "brother/boy" chatterings accompanied her next across-the-board re-positionings, which were concluded with a "Stay" command. The #2 clown was placed last, nearest herself, and the #4 clown was still ignored:

	1
	3
4	5
	6
—	2

With the board turned around, the #4 clown replaced the smallest ('baby') clown, which was put on the centre, #5, clown (i.e. in the mummy's lap). Of all Jessica's placements and replacements of the clowns, nine were with her right hand, three were with her left hand, and two were simultaneously with both hands together.

The alignment of the #5 clown at Jessica's midline with the #6 clown to its immediate right is comparable to her centred and adjacent placements of the largest dogs: #6, underneath-side-up, at the left of her midline and #5, right-side-up, at the right. Also, again the smallest three were placed in sequence and again the #4 cutout was isolated and neglected:⁸

6 _ 5 1 2 3 ... 4

Twice, at the start and finish of these placements, the two largest dogs -- one in each hand, one forwards, the other

⁸Freud (1914, p. 289) reports the explanation of a patient who spoke a series of numbers but omitted the numbers three and five:

We were altogether 7 children, I was the youngest. Number 3 in the order of the children corresponds to my sister A., and 5 to my brother L.; both of them were my enemies. As a child I used to pray to the Lord every night that He should take out of my life these two tormenting spirits. It seems to me that I have fulfilled for myself this wish: '3' and '5,' the evil brother and the hated sister, are omitted.

Rather than this negative, blocking, reaction, the salient numbers for the children in this sample seemed related to preferences in their one-to-one correspondences: For Amelia, the only child in her family, numbers one and six were preeminent, as in the centre position of the #1 clown but the midline position of (and repeated contact with) the #6 clown, and her pairing of these two when she began the collection; also, she both placed and collected the #1 dog first and the #6 dog last -- although the board position of only one was at an end. Likewise, for Simone, the other only-child, both the #1 and #6 clowns were centred and abutted in the small-large groupings; the #1 and #6 dogs were adjacent, abutted, and placed last. For Lucy, the youngest of the three children in her family, preference was for "the tiny one" ("the Lucy one"): The #1 clown and the #1 dog had embedded positions, yet the one was the first placed and last removed and the other was placed at her midline and removed first. For Jessica, the middle child, the #2 clown had two special placements, and it was the #4 clown and dog cutouts (which would have no counterpart in her family if the smallest were to represent her little sister and the largest her father) that were repeatedly excluded.

backwards -- romped around the board (twice in the first instance pouncing on the smaller dogs, once with a voracious vocal slurp). The finale was that these two largest dogs were spanked and scolded, "Bad, bad, you-two", and the three smallest were praised, "Good all-of-you".

While in the demonstration set only the first ball had been placed with her left hand, Jessica initially placed only the last dog with her (right) hand. The dog replacements, however, were equal: three right-handed and three left-handed. Only the large pair was placed originally and collected and inserted into the envelope simultaneously with both hands. (The other dogs, and all the clowns, were inserted into the envelope with her right hand, one-by-one.) With that simultaneous collection, the largest dog was the only one collected with her left hand, the opposite of her sole right-handed collection of a clown.

Jessica's equilibrations in these Task B examples, as in the example of her Task A middle-card first or last placements, were not exceptions. In Task C, similar balances were also paramount.

With the demonstration shapes, selected individually from the board, the placement of a yellow triangle at her midline was with both hands; all her other correct placements were with her right hand, but two of her three incorrect placements were -- the only ones -- with her left hand.⁹ For all three test sets, with the pile of shapes held in her right hand, the only shapes *not* placed with her left hand were a next-to-last shape and two last shapes, plus two squares placed simultaneously around a triangle at her midline. Only the purple shapes were not placed from the top of the pile straight down, or strictly from left to right; they, like Lucy's, composed three discrete triplets (with none of either child in the correct square-triangle-circle order):

t, c, s; t, s, c; t, s, c

Also, only the purple shapes were put one-by-one into the envelope. The shapes of the other two sets were collected cumulatively, from left to right -- all but two of one set with her left hand and all but two of the other set with her right hand.

Unique to Jessica was her assiduous repetition of the colour names throughout all her collections. Signing was simultaneous with pick-ups and continued after she had

⁹Recall that exceptions in Amelia's rightward placements and leftward collections were the actions of her left hand, and that a single midline insertion of Polly's deviated by having been made with her left hand.

retrieved two dropped shapes. All the while she looked at the examiner only three times (not at all during the collection of the first set; once, after a sneeze and a shape retrieval, during the second; twice during the third). The complement of her inserting the shapes into the envelopes with her right hand was her extending the envelope to the examiner each time with her left hand.

Jessica's interim posture alternated between sitting with her fists centred yet with her knuckles opposed, having both fists on her hips, and extending both arms at the ends of the board. These positions epitomize her many contrasting but complementary actions.

Simone, vis-a-vis Lucy. As the youngest deaf girl in the Main Study, Simone contrasts to Alice, who is the oldest. As an only child, she is like Amelia. She is one of the two deaf girls tested who was in the oral class. The cause of her deafness was reported to be 'unknown' and the degree to be greater than 70 dB. She wears glasses to correct an unspecified visual impairment. Her parents reported that they and other relatives are right-handed but indicated (with a 'right-handed' entry crossed out) that Simone is ambidextrous.

Simone's Task Handedness Ratio of .266 is just below the .292 mean for all the children; however, her Inventory Handedness Ratio of .818 is way above the total mean, of .340.¹⁰ Ten of the Inventory handedness items were executed with right-hand dominance; the single left-hand dominance was in her unique manoeuvre of stretching the rubber band with her left hand from around her right hand to around the box. She sighted with her right eye, but used both feet equally, concluding her right- and left-foot hops with jumps.¹¹

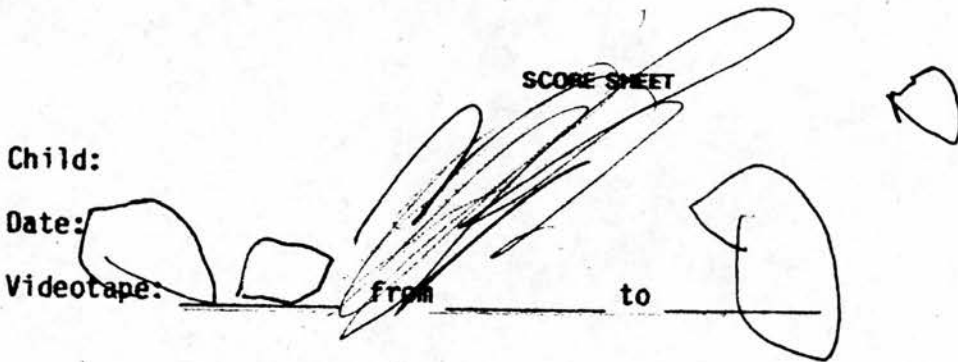
Simone shares with Lucy the highest IHRs, the lowest ranges, and the lowest scores of the six girls. Simone's total score is 2.3% higher than Lucy's; her ASD ranking of 43 among all 60 children (11 among the 20 deaf children) is 15 places above Lucy's. Also shared is the combination and progression of task scores and ratios (the highest score combined with the

¹⁰This discrepancy between her THR and (higher) IHR, by .552, has an association with left-handed children: Of the five children whose IHR differences are greater than Simone's, three are left-handed (i.e. nearly half of the left-handed population) and one other has familial left-handedness.

¹¹During indoor play, when not nestled inside the giant play tyre, she would jump vigorously on the trampoline, up to 25 times in succession, with her feet to the bar, almost reaching pike positions (i.e., with mid-body, waist, bends, in contrast to the other children's bent-knee, feet-down, bounces). Her opossum swings on the bar had alternate hand-foot positionings, and ended in back flops. At outdoor play, she rode a scooter with her left foot on the runner, treading with her right foot.

lowest ratio, on Task B, to the lowest score with the highest ratio, on Task C); the same *duration* percentage of two-handed contacts (both 81%), and similar right-hand and left-hand percentages; midline crosses made only with their right hands; and a similar number of transfers, but with a directional inversion, as 81% of Simone's transfers were to her left hand, while 75% of Lucy's were to her right hand. Another inversion is in the frequency of Placement and Collection contacts: Whereas Simone used her left hand more to collect than to place the objects in the three tasks, Lucy used her left hand more when placing the objects.

Lucy's characteristic dichotomies were also apparent in Simone's actions. An important difference, however, is that while Lucy's handedness patterns are marked with asymmetries, Simone's are marked with symmetries. For Lucy, the nature of the dichotomies was oppositional; for Simone, they have a complementary quality. An example of Simone's leftward orientation and symmetries is her signature, reproduced below. (The circles were drawn towards herself -- clockwise at the left and counterclockwise at the right.)



Simone constantly centred the materials, as if to stabilize a midline left-right divide. Whether she picked up and placed an object with her right hand or with her left hand depended upon whether it was at her right or left side; rather than crossing her midline, she would alter her position. (The once she did reach across her midline, she fumbled in grasping the material.) But before placing an object, she incorporated an in-between movement: She would adjust it with both hands at her midline. Likewise, collections were to her midline, where each object was added one-by-one to the others held in her other (usually left) hand. A description of her spontaneous placement of the shapes in the demonstration set will illustrate her style, including her centre-out movements, leftward predilection, and symmetries. As this was her first task, the description begins with her introduction to the materials.

Simone slapped both hands on the empty board, then rotated this palm-downward position into an

interrogative ["What?"] gesture, looking at the examiner.¹² Immediately, with a series of double index-finger points, she tapped first out, then in to the middle of the board, then rightward, then to the envelope. Her gestures during the examiner's "red, yellow, white" recitations of the pattern were 11 right-hand ["gimme"] squeezes with an "ə" vocalization preceding a left-hand ["What?"] poised movement.¹³

Her first placement was of the top shape in the pile, correctly at the right of the sample set. Since the order of the shapes in the stimulus set is red-yellow-white and it was a yellow circle, it was removed by the examiner to the lower board at Simone's midline. Instead of selecting another shape to repeat the sample pattern, Simone built upon that central yellow circle (Y) in an 8-7-6-5-2-1-Y-3-4 progression with the shapes in pairs (the first three of large white and small red rectangles, the last of yellow circles). The first two shapes placed were patted twice each; the circles were dropped at her midline. She placed the two shapes to the right of her midline with her right hand, those to the left of her midline with her left hand. The two times she changed hands, she transferred the pile of shapes to her other hand. Having completed her pattern, she sat back with a sigh and a smile, her fingertips at the board edge (her most typical position).

In response to the examiner's prompt to find a red rectangle to continue the pattern, she made a vociferous protest, with a repeated bilabial plosive ("p/b") and two series of two-arm waves. Simultaneous with the examiner's snatching up a red rectangle, Simone exclaimed with a lip-smack, and complied. Following the examiner's points to the next sample shape and to its intended position, Simone correctly chose the yellow circle (still at her midline), raised both arms, and placed it with her right hand. She then picked up another red rectangle, with another imitation snap, of her hand and head, and an "eə" vocalization. Removing it when prompted, she pointed to the correct (white) shape, at her midline, simultaneously with fingers of both hands. After its placement (and squirms and chair adjustments, with her tongue between her teeth), Simone pointed first to another white shape at the right with her right index finger, then to the other white shape at the left with her left index finger [e.g. "If one white is right, why not another ... and another?"]. That white shape

¹²Inferred translations of her gestures and vocalizations are bracketed.

¹³Simone's prevalent vocalization was a prolonged schwa (ə) sound -- a neutral, unstressed, open-mouthed, mid-central vowel (which sounds the same whether the tape is played forwards or backwards), i.e. a vocal analogue to her other centrings and symmetries.

was the last placed in error: Thereafter, each choice was made with a point (downwards) and a look (upwards) until it was confirmed.

Eight of the 10 shapes she placed (one twice) had two-handed midline adjustments. The two shapes placed directly were the first one and the white shape at her midline. Eight were placed with her left hand; the first and the last were placed with her right hand (the last with an extra pat).

Simone imitated the examiner's blocking checks of the sets with a two-handed chop at the middle of the board, then with four rapid chopping repetitions:

|| ←→ || --> ||

After more tussles with the chair, again with her tongue protruding, she knelt on the cushion and held both hands palm-up, vocalizing "aɒ", and then slapped them on the board -- a repetition of, and full circle return to, her first action. Seated again, she folded down the right side of the board, the first of 12 up-and-down folding episodes (with one breaking the board).

The patterns in this segment, lasting three-and-a-half minutes, prevailed throughout the total 31 minutes of the testing. Two-part designations were elaborated in the following:

- Placements of the clown cutouts: Like Lucy, Simone separated the smallest and the largest clowns. The three smallest were chosen first, in the correct sequence, and were placed horizontally, the #2 clown below, the #3 clown above the smallest. The other triplet was placed first vertically to the right of the smallest clowns, then also horizontally to their left; the smallest of these was also the first placed and replaced. Within both triplets, the smallest and the largest were in the central position.
- Colour repetitions: Each of Simone's elicited recitations of the blue, red, and yellow colours in a stimulus set was a tongue-between-teeth "m" vocalization combined with a movement of raising both arms. Next she pointed six times to where the test shapes would be placed -- in imitation of, but doubling, the examiner's three points. Points to the sample shapes in the next set were doubled twice. (They began with the middle shape, then moved both towards and away from herself -- vertically as she was lying along the board.) The distribution of her dozen taps (the middle three with double taps) was three to the furthest-away shape, four (the mean and median number) to the middle shape, and five to the shape nearest her.
- Picture-card contacts: Twice in the demonstration set, a centre placement was made with both hands together; two placements and two collections were at the left and

right simultaneously. Initial placements of 12 cards were at her midline (five) and rightwards (seven) -- all with her right hand; the three to the left of her midline were all placed with her left hand. (The one card held in both hands while being studied silently for 17 seconds was placed on another card, starting her collection.) Cards on the board were always contacted again -- simultaneously in pairs, with her hands parallel: When three cards had been placed, additional contacts were always with the card at her midline and an adjacent card. The single alteration, of a two-card set, was made with an exchange of the card from her left hand to her right hand, neither hand traversing her midline; that also was followed by a two-hand left-right contact, as she centred them. Collections were similar, again in pairs and still not crossing her midline; in two sets the middle card was collected with her left hand, in the other two sets with her right hand. None of the cards were put individually into the box: They were all amassed first with both hands at her midline -- by twos again, always with the rightward, right-hand, card and all but one of the third-card additions collated over the other(s), i.e. for 13 of the total 14 shuffles. (One left-over action was begun, then reversed in a left-under motion.) Except for the two-card sets, placements were made with the cards taken from her left hand; collections were to her left hand.

Other complementary actions included the following:

- Body positions: The four times Simone lay across the board reaching for test materials, she obtained a balanced position by simultaneously extending her opposite leg.
- Wrist twists: Inversions of the materials abounded. For example, in the demonstration set described above, six of her 10 shape placements were executed with a flip: In her midline two-hand adjustments, the top corner of a shape was pinched; then with a wrist rotation, the shape was turned over, i.e. released with her fingers at the lower corner of the shape. This was her method of placing the last two pairs of triangles and rectangles, but not the intervening square. Likewise, in her collections of nine of the 12 shapes in this set, the shapes were picked up with pinches at the near corner and then flipped when placed on the pile, resulting in a final away position. This sort of wrist twist was common among all the children -- when they were turning over the one-sided picture cards and circus cutouts, but not when they were handling the reversible shapes. The twisting movement of Simone's anticipation and conclusion cycle of slaps on the board accompanied, either before or after, by a palm-up gesture was varied with slapping and then reaching movements of both hands. Simultaneous index-finger points to the two cards of one set were with her left hand down (at the burst balloon) and her right hand up (at the blown-up balloon). The cards of the other two-card set were held simultaneously with her right hand under the one and her left hand over the other.

- Head shakes: Twice her head shakes of refusal were reversed into nods of acquiescence. Simone controlled the testing procedures, as well as her movements, but in a give-and-take relationship with the examiner.
- Tongue movements: Her prominent tongue position was just that -- a protrusion. Modulations were lip licks and a series of 12 up-down movements accompanied by sideways fingertip taps.
- Adjustments of the circus cutouts: As Simone had straightened the shapes of one set, moving them one-by-one more leftward, she also made diligent replacement alignments of the clown cutouts in the larger and smaller groups and of the dog cutouts, abutting the heads with the feet of the clowns, each nose with the preceding dog's tail. Envelope insertions of the three smallest clowns were sidewise; of the three largest, they were vertical (with an initial head- to feet-down adjustment). Table adjustments between the smallest and largest clown placements were made with transfers of the pile: pulling the table in at the right with her right hand, then at the left with her left hand; at the conclusion of these placements, with both hands centred, she pushed the table out.
- Shape matchings: In the first two test sets, Simone collected all the shapes of the same colour separately, each in a middle-->left-->right order. However, her collections of the all-purple shapes were in a straight right-to-left order; all but the first one were collected with her left hand and put one by one into the envelope held in her right hand.
- Circus ball drops: Middle-->left-->right movements were seen also in Simone's extraction of the demonstration-set picture cards from the examiner's hand and, with a final return to the left, in her selective ordering of the demonstration balls that she dropped from the edge of the board to the floor (her game after a missing ball had been retrieved from the floor): All but the furthest right ball (removed from the board with her right hand and transferred to her left hand) were obtained and dropped with her left hand at her left in a 7-6-2-1-3-4-5 order (one twice).
- Communication: Simone's language repertoire consisted of complementary vocalizations and gestures. Together, as a comprehensive 'both-and' statement, they contrast to Lucy's 'either-or' absolute terms.

In these many ways, Simone has shown asymmetries and yet an equilibrium. The mischief, e.g. with the board raisings and lowerings and the drops and retrievals of the balls, illustrates the oppositional but complementary nature of Simone's actions even in play. Neither they nor her low scores should misrepresent her response to the tasks -- an attitude of conscientious application. She simply made what sense she could of the tasks, and displayed what she does know, explicitly and consistently.

Alice, vis-a-vis Polly. Tested just 12 days after her seventh birthday, Alice is the second oldest child in the studies. She was two years and nine months older than Polly and three years older than Joel, the other perfect scorers. Differences in their handedness patterns probably relate to differences in their ages, perhaps also to hearing status.¹⁴

Alice has Waardenburg's syndrome with a profound bilateral hearing impairment. (The speech-frequency average is 107 dB for her left ear and 108 dB for her right ear.) Her only sibling, an older half-brother, and her mother are also deaf. Her natural father is reported to be hearing. For him, no handedness information was available; for the others, right-handedness was reported. Although Alice's handedness indices also show her to be right-hand dominant (with a THR of .490 and an IHR of .375), a 1985 entry in her Record of Needs indicates a left-hand preference, and a teacher has reported that Alice sometimes writes 'for fun' with her left hand. Ambidexterities in the Inventory include Alice's initially throwing the ball with both hands and clapping with both hands centred, spontaneously shooting the marble with each hand, and simultaneously spinning the small tops with both hands. She was equally adept at kicking the ball with and hopping on either foot. When she bounced the ball, with her right hand, she moved in a clockwise circle.

Similarities of Alice and Polly already mentioned include their perfect scores, Band I IHRs, and their coordinated use of both hands. Alice resembles Polly in other ways as well, surpassing her in some. Alice also was economical, and comprehensive, in her expressive language. She rarely signed except in response to questions, simply nodding and/or signing and saying "Yes" in response to instructions. Yet she too extended her descriptions: When naming the shapes, she spontaneously added their colour and size attributes -- although with inversions of word order (e.g. "Square, small purple", "Triangle, purple big", and "Purple big round"). In her descriptions of the picture-card sequences, some expansions were inferences, some explanations; none of her comments were irrelevant digressions. For example, when

¹⁴Age, a factor that correlates significantly with task success, cannot alone account for Alice's superior performance (as it does not for the much younger children). Rather than explain that Alice did so well because she is older, it might be more apt to question how much younger she might have been and still done as well. For comparison, the five oldest children tested, all deaf, are listed below with their scores.

	Age	Total Score	ASD Rank
Jimmy	7:6	40%	60
Alice	7:0	100%	33
Bruce	6:9	66%	53
Gayle	6:8	70.3%	44
Daniel	5:9	69.7%	45

queried about her placement of the apple pictures in the demonstration set, she replied with a summary extrapolation: "Because she[-point] very-hungry."¹⁵ The four times she was asked, she was able to suggest continuations to the pictured events. Her story extensions and other continuations reveal perceptions not only of isolated particulars but also of totalities.

Continuities were shown in her cumulative one-hand collections of the materials. While Polly's collections in Tasks B and C were cumulative (with items picked up one after the other and put all together, not one-by-one, into the envelopes), all Alice's collections were cumulative. Also, she did not right the upside-down cards individually: She turned around the pile of cards.

Alice, like Polly, completed all the tasks with strict attention and without distractions. When there were noises from others in the room, she would look up but continued with her work. As well as at the end of the placements and collections of the sets and during her picture descriptions, she looked at the examiner for confirmation during her independent errorless placements of the demonstration sets, after the start of two pattern repetitions, after measuring two of the dog cutouts, while placing only one of the 25 picture cards, when (with a smile) she corrected three errors, and when she detected the small white circle trick. (Her reaction, and Polly's, to the trick was to query it visually; then, while discarding it, to laugh, maintaining eye contact with the examiner, sharing the joke. The other four girls merely incorporated the small circle in their placements, although Amelia commented on it and giggled.

Alice's actions were methodical, without excesses or imbalances. Materials were separated at the table edge -- the demonstration cards in her last task (A) with no prompt -- before being placed in the centre of the board, without comment, and with each shape patted when placed. Waiting until the examiner had recorded her placements, she spontaneously initiated the collections, but began her descriptions of the picture-card sequences only when asked. The total testing time for Alice was 25 minutes -- the fifth fastest time of the 60 children. (She was faster than Polly by three minutes, the other two hearing girls by 10 minutes, Simone by six minutes, and Jessica by 16 minutes.)

Her collections of the materials provide examples of the

¹⁵That deictic reference was exceptional: Whereas most of the children accompanied their descriptions with card-by-card pointings, Alice pointed only to the first two cards of that demonstration set and to one other during her elicited descriptions. Instead, she would shift her position in the chair, her eyes and signs moving along with the narratives.

efficiency and flexibility of her movements. As recorded in Table 6.3b in Chapter 6, Alice used one hand exclusively to place and collect all the materials in more sets than the other five girls, and used both hands equally the least (for only one placement, when she placed both picture cards of a set simultaneously with each hand). In addition to her one-handed collections of all the items in nine of the 11 sets completed by all the children, Alice also collected the nine picture cards of sets 7 and 8 and all the demonstration balls with only her right hand.¹⁶ These and all the items in three other sets collected exclusively with her right hand were collected in a right-to-left direction; the four sets collected exclusively with her left hand were in a left-to-right direction. Her collection of the purple shapes was also right-to-left with her right hand, but the three different shapes were collected separately. Exceptions were the shortest, two-card, picture sets: In both sets, both cards were collected with her right hand but from the left. Including the one demonstration set, seven collections were begun at the right with her right hand and seven at the left with her left hand -- none with Polly's vacillations or adherence to a restricted right-to-left direction.

Alice's left-at-left and right-at-right rule had adaptations for the placements. All placements, apart from self-correction insertions, were in a left-to-right direction.¹⁷ There was a progression in her right-handed placements of the shapes: from seven in the demonstration and first sets to eight in the second set and then all nine in the last set. Left-hand patterns are Alice's using her left hand for initial placements at the left, for shapes placed just at the left of her midline, for the one simultaneous two-card centre placement, and for consecutive left-right pairs in final placements. Exceptionally, only one placement was made with both hands on an object (the last shape placed in the demonstration set). Other parallel contacts were placement adjustments and a tentative two-handed exchange of the middle cards of set 7. Another handedness coordination was her use of her left hand to point to shapes already placed while choosing and placing next ones with her right hand, and to question the first collection by contacting the left-most shape with her left hand while miming a collection with her right hand. Also, when she replaced the rubber band, her left

¹⁶Because of these extraordinary regularities, the two sets with items not collected with just one hand were examined. In a three-card set, the card at the left was moved to the middle card with her left hand, then they and the card at the right were collected with her right hand; in the clown set, the last, smallest, clown at the left was added with her left hand underneath the other clowns, collected from the right with her right hand.

¹⁷Including the demonstration sets, 81% of her 81 placement contacts were right-handed, yielding a mean ratio of .649 for placements, in contrast to a mean collection ratio of .321.

hand held the box while her right hand stretched the rubber band around it in a double twist -- a technique used successfully by only one other child.

Other examples of Alice's right-left equanimity are her transfers of materials, 28 to her right hand and 27 to her left hand; her independent right- and left-hand midline crosses; and her signing: Approximately one-third of the one-handed signs Alice used were signed sometimes with one hand and sometimes with the other hand. A one-handed sign was signed with both hands, and some two-handed signs were signed with one hand. A major complement was in her use of total communication, simultaneously signing and speaking.

A symmetry was her placement of the materials: Both test sets of the circus cutouts and the last five picture sets were placed symmetrically, half at the left of her midline and half at the right, with middle objects at her midline. (Even the ring she wore was centred -- on the middle finger of her right hand.) Also, she centred herself: She stood while placing the clown cutouts and while collecting all the circus cutouts, and all the shapes in two sets.

An interim posture was similar to Polly's and Amelia's, with both hands at the sides of her chin, but most often, at the completion of the placements and between sets, her hands were clasped (once woven tartan-style).¹⁸ Alice's hand clasps would seem to be symbolic of a total integration.

CONCLUSION

These portraits show the individuality of the six girls. In their various but consistent ways, with their hands and words, they expressed their systems and their understanding of the tasks. In that, whatever their scores, they all succeeded.

REFERENCES

- Erikson, E.H. (1977) *Childhood and Society*. London: Triad/Paladin.
- Freud, S. (1914) *Psychopathology of Everyday Life*. London: T. Fisher Unwin.
- Piaget, J. (1959) *The Language and Thought of the Child* (Third Edition). London: Routledge and Kegan Paul.
- Stokoe, W.C., Jr, D.C. Casterline, and C.G. Croneberg (1965) *A Dictionary of American Sign Language on*

¹⁸The oldest child, who has the lowest rank score, typically sat either with his arms at his sides or with his hands placed on the board at his midline, but with his right hand over his left hand or with fingers of his right hand grasping fingers of his left hand -- i.e., without union.

Linguistic Principles. Washington, D.C.:
Gallaudet College Press.

APPENDIX H

HANDEDNESS-SIDEDNESS INVENTORY (HSI)

The Handedness-Sidedness Inventory was developed as a supplement to the handedness ratios obtained from the children's contacts with the sequencing task materials. The intention was to have a more general representation of hand preferences and also a measure of foot and eye preferences. As an addition, it was important to have the Inventory short, taking only about ten minutes to administer to each child.

The activities in the HSI are shown on the attached score sheet. Some were selected from those used in the Preschool Handedness Inventory and Preschool Fine Motor Scale developed by Lesley Tan (1985 and personal communication).

MATERIALS

- a 5-inch rubber ball
- two 1-inch wooden tops (with a .3cm-wide, 1cm-long stem)
- 25 1-inch coloured wooden cubes
- coloured round wooden beads of assorted sizes (six measuring 1cm and six measuring 1-1/2cm with .3cm holes; six in pairs measuring 1.2, 1.6, and 2cm with wider holes, from .7 to .9cm)
- strings (one of leather .1cm thick, the other of cotton .2cm thick)
- glass marbles (of 1cm and 2cm sizes)
- a wooden yo-yo (1-1/2in, with a .2cm-wide groove and 1cm-wide, 30in-long string)
- a slate (22x16cm) with white chalk and an eraser (13x4cm)
- the Task A box (3x4-3/4in) and rubber band (2-3/4in long)
- a kaleidoscope (4-1/4in long with an aperture .8cm wide)
-
- folding flannel board (14x39-1/2in)
- scoresheets and pen
- the videorecorder
- timer

The Inventory test items were selected partly for portability, so that all except the ball could fit inside a 12x7-inch container. To give the children a choice and to minimize an age bias related to difficulty of manipulation, different sizes and numbers of objects were provided. (For example, the two thicknesses of strings and the two widths of the bead holes gave different levels of challenge, and the quantity of blocks allowed for them to be stacked until they fell.)

PROCEDURES

The HSI was conducted in the testing room used for the sequencing tasks, usually at a separate and subsequent time and with two friends working together. To avoid a left or right bias, the materials were presented at the midline of each child, and when the boxes of cubes and beads were between the children and shared, the children exchanged positions mid-way through the tasks. Tasks were demonstrated only when a child did not initiate an action.

For the three initial trials of the first six items (throwing, bouncing, and kicking a ball; hopping; spinning a top; rolling a marble), the hand or foot the child used spontaneously was recorded. Whether or not the child was able to do the activity twice upon request with the other hand or foot (also to spin the top with both hands simultaneously) and the child's final preference were noted in the other three columns.

For the next three items (stacking cubes, threading beads, and winding the string on the yo-yo), Oldfield's (1971) distinction about the dominant hand when threading a needle was used: The active hand was defined as the one placing the cube, and the one moving, not simply holding, either the bead or the string, the yo-yo or its string. The actions with at least six cubes and beads were recorded.

The hand used to draw and erase a picture (of whatever the child chose) and the eye used to look through the kaleidoscope were noted. The last three items of the session (hand claps and clasps and armfolds) correspond to those included in the parents' questionnaire and the University students' survey and were analyzed separately (see Appendix C).

Of the activities at the bottom of the Inventory scoring sheet, name writing, button pressing, videotape viewing, lid and rubber band placements (with the box containing the Task A picture cards) had been observed and recorded during the sequencing task testing. Walking up and down stairs and skipping were observed, when possible, while going to or from the testing room.

Additional information recorded was about a child's motoric style (such as underhand or overarm throws of the ball), deviant directions of the ball when thrown or kicked, colours and sizes selected, successes and difficulties (e.g. inability to hop or to use the yo-yo), and comments the children made. The table activities of the first hearing child and the first deaf child tested and most of the children's drawings were videorecorded. Ratios were calculated from the score-sheet information for the preferred hand, foot, and eye (separately and together), again using the $(R-L)/(R+L)$ formula.

RESULTS

The handedness ratios obtained in the Inventory (the IHRs) are discussed in the relevant chapters, with the information on the handedness ratios obtained from the sequencing tasks. Here they are reported as they relate to the other Inventory ratios, those for foot and eye preferences.¹

Table H1: HANDEDNESS-SIDEDNESS PREFERENCES*

	-1	-.333	Foot 0	.333	1	-1	Eye 0	1	-	Hand	+
Deaf children (n = 20)	1	2	10	2	5	8	2	10	3		17
	(15%)		(50%)	(35%)		(40/10/50%)			(15%)	(85%)	
Hearing children (n = 40**)	1	2	15	6	15	9	3	28	4		36
	(8%)		(38%)	(54%)		(22.5/7.5/70%)			(10%)	(90%)	
	(10%)		(42%)	(48%)		(28/8/63%)			(12%)	(88%)	

* - = left preference
0 = left and right preference
+ = right preference

** A foot preference was not obtained for one hearing child.

As shown in Table H1, all three measures were lateralized to the right: handedness the most (88%), footedness the least (48% -- with 42% ambipodal and the overall median 0). The most left-lateralized preference was exclusive left eye use (28% -- comparable to the one-third left-eyed representation of Glasgow school children studied by Clark [1957]). Although the differences between the deaf and hearing children are small, they are consistent: Greater proportions of the deaf children are left- and non-lateralized. (Their mean handedness ratio, for instance, is more leftward: .371 versus .451 for the hearing children.)

When hand, foot, and eye preferences are considered together, the right dominance of the hearing children is accentuated and is more consistent: 49% of them have positive ratios on all three measures, in contrast to only 10% of the deaf children. For all the children, the most congruent ratios are for hand-eye lateralization: 68% have either positive or negative ratios for both measures, versus 49% for hand and foot congruence, and 47% for eye and foot congruence. Again there are differences between the deaf and the hearing children in overall distributions: The deaf children had less congruous, i.e. more mixed, preferences (Table H2).

¹Audiological information was available for eight of the 20 deaf children. Only slight (1 to 7 dB) right and left-ear differences were detected: For four of these children (who are all right-handed), the right ear had the better speech-range acuity, for two the left ear had, and for the other two children both ears had equal acuity. (Note that hearing acuity -- like visual acuity and foot or hand skill -- is not necessarily the same as preference.)

Table H2: CONGRUENCE OF PREFERENCES

	Hand=Eye	Hand=Foot	Eye=Foot
Deaf children	55%	30%	25%
Hearing children	75%	59%	59%

Congruous lateral preferences of the hearing children were not differentiated by their individual sequencing task scores. However, oddly, among the deaf children, those who were bottom-rank scorers had a greater incidence of congruence: Their incidence of hand and foot congruence was two times greater and their incidence of eye and foot congruence was four times greater than for the deaf top-rank scorers.

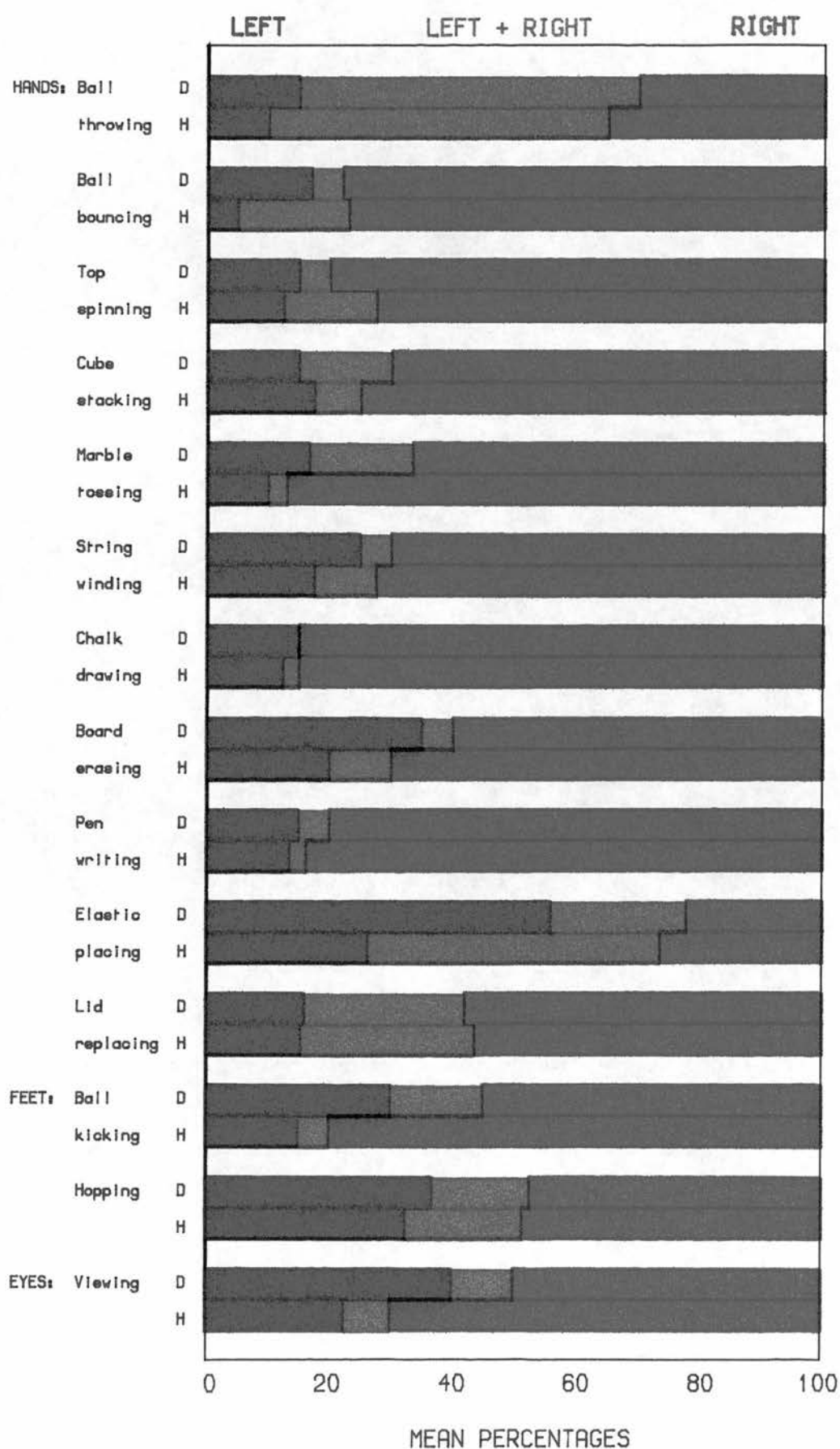
The results of each Inventory item counted in the ratio calculations are shown in the graph. Most obvious is the similarity between the hearing and the deaf children. The absolute percentages, however, indicate the left-right preference differences: In 13 of the 14 activities, proportionately more deaf than hearing children had a left-sided preference; in 10 activities, proportionately fewer deaf than hearing children had a right-sided preference).

DISCUSSION

What was most remarkable about the children's approach to the tasks was their ambidexterity: Both hands were often used simultaneously and with alternating dominance. This tendency is somewhat obscured in the figures, as the counts are based on the majority of a child's movements during each activity and his final preferences, which were not always the same as his initial choices. In a few cases, preference was equated with ability, e.g. when a child was unable to do the activity with the other hand or foot (or eye in the case of the child reported to have no effective vision in one eye). These default preferences, and abstentions, were seen in the more difficult activities of spinning the tops, hopping, and bouncing the ball. (Thirteen of the 44 children who spontaneously attempted to bounce the ball with their right hands, and one of the five using their left hands, were unsuccessful, and three children did not try at all.) When there was any indication of partiality to one side, that side was counted; ambidexterity (a left and right recording) was reserved for those actions in which no preference was discernible.

A presumption had been that certain tasks would be facilitated by using both hands together, but that one hand would be consistently dominant. The expected bimanual division of labour was that one hand would be active, the other supportive. However, equipotentiality was frequently observed, as well as an ipsilateral preference -- to use the hand in closer proximity to an object. For example, instead of obtaining and stacking the cubes and making precision adjustments with one hand while the other hand held the column stable, a child would use both hands actively, variably using

HANDEDNESS-SIDEDNESS PREFERENCES



either hand for any of the movements. Also, instead of holding the yo-yo still in one hand while the other wound the string in the groove, some children would move only the yo-yo and others would (at least begin to) turn each hand, the yo-yo and the string, in opposite directions. (There was a preference in the direction of the winding: About half of the children wound away from themselves -- with whichever hand; of the other half, twice as many wound towards themselves as wound alternately away from and towards themselves.) Particularly when placing the loose rubber band around the box, children would use both hands equally: Only 12 children used one hand dominantly -- nine the left (including only two left-handers) and three the right (two making a sophisticated double twist). The other 44 children recorded tried to girdle the box, with both hands symmetrically stretching the rubber band, and with only half of them later making a one-handed adjustment. Likewise in replacing the lid on the box, many children had a two-handed approach, using both hands in parallel.

The way the children threw the ball further illustrates how generally when a task could be done with two hands, simultaneously, that is how it was done. All but three of the 60 children spontaneously threw the ball with both hands rather than with only one hand (most in an underhand position); that was also the final preference of most of the children, as can be seen in the graph. (Age does not account for the immediate choice of the three children to use only one hand -- their right hands: The mean age of these hearing children was 4.09, i.e. below the overall and hearing means. More compatible was their rightward mean, and median, IHR of .667.)

Bilaterality was also expressed in how the children wrote their names and drew pictures. The youngest child held the pen in both hands when scribbling his name. Three right-handed children, in addition to the ambidextrous boy (whose split name-writing has been illustrated), alternated hands when writing their names. The other ambidextrous child and the left-handers wrote with their left hands; all the left-handers also drew with their left hands. While both the ambidextrals alternated hands while drawing their pictures, so did seven right-handers. When erasing their drawings, even more children were inconsistent: Four had both hands on the eraser, 10 others changed from their left to their right hands, and 15 (including seven right-handers) erased with only their left hands. Therefore, one more than half of the children used the eraser exclusively with their right hands. In spite of these individual variations, the overall proportions of the children who wrote with their right hands (84% of the hearing children and 80% of the deaf children) and who drew with their right hands (85% of both groups) are similar to the right-handed prevalence found in other surveys (e.g. of 80-90% for a right-handed writing or drawing preference in the Cermak, Quintero, and Cohen [1980] study of 150 four- to eight-year-old children).

It was because of dominance ambiguities and ipsilateral preferences that two activities were eliminated from the handedness calculations. In the bead stringing, most children (approximately 73%) held the string in their left hands, but only most of the time and with several variations, such as either pushing the string through the bead or pushing the bead onto the string (like Huckleberry Finn did when disguised as Sarah Mary Williams), either pulling the string out or pushing the bead down -- and changing hands throughout. To have ascribed dominance to either hand would have belied the essentially bimanual manner in which most of the children performed this task: *Both* hands were active.

The pressing of the buttons on the video remote control and the timer was also excluded, this because of a position bias. Most frequently the fingers used were those nearer a button: 81% pressed the left buttons with their left fingers; only 19% used their right fingers exclusively, i.e. for buttons at the left as well as at the right.

Three children were exceptions (not counting the three who ingeniously/cheekily attempted to kick the ball with both feet at once). One child who had previously failed to spin a top with either hand did succeed in spinning both tops simultaneously. In contrast, the other two children had considerable problems coordinating their hands. Hamish is one who drew first with his right hand, then with his left, and is one of the children who has a squint. He is the only child who wrote his name backwards, and from right to left, i.e. as HSIMAH.² He stacked nine cubes with his left hand, all the while keeping his right hand under the table; he stopped after stringing only four beads; and after 2-1/2 minutes of attempting with both hands to put the rubber band around (even the sides of) the box, he -- and only he -- declared, "Can't do it."

The other child who also had great difficulty with the rubber band is Jimmy, the lowest age-ranked scorer. He and the youngest deaf child were the only other children who ultimately did not succeed independently in placing the rubber band around the box: After one minute and eight attempts, with both hands stretching, even diagonally twisting, the rubber band on and along (never *under*) the box, he stopped, smiled, and accepted assistance.

²The first and last letters of his real name are not the same, and five of the six capital letters are symmetrical, like all but the 'S' in 'HAMISH'. Rather oddly, five days before he had made only two of the letters approximately correctly: The 'O' was angular and another letter was upside down.

SUMMARY

When doing the HSI activities, the deaf children showed greater left-sided preferences, the hearing children greater right-sided preferences. This trend is seen in the group percentages within the foot, eye, and hand categories and within the itemization of each activity. These lateralization differences substantiate the differences between deaf and hearing children reported in other studies (see Chapter 1). On the congruence measure, of preferring the ipsilateral hand and eye, hand and foot, and eye and foot, the deaf children had more mixed dominance, the hearing children more consistent dominance. This congruence relates *in general* to the mean sequencing task scores of the deaf and hearing groups: Less congruence is associated with the lower scores of the deaf children, and greater congruence is associated with the higher scores of the hearing children. The mixed lateralities of the deaf children and their lower mean scores is a result in accord with Orton's (1937) report of the co-occurrence of mixed motor patterns ('crossed sidedness' or 'intergrades') and disorders in language development, specifically in children's reading, writing, and speech problems. Others also consider mixed patterns a detriment, associating them with 'neurotic troubles', stammering and other speech defects, strabismus, difficulties in kinaesthetic control, and academic 'backwardness' (Burt 1958); with spelling retardation (Naidoo 1972), reading disabilities and linguistic retardation (Clark 1957), a higher incidence of writing errors (Kósa-Jekkel 1990), lower speech ratings among deaf children (Gottlieb, Doran, and Whitley 1964), and lowest quartile ranks in reading, in addition to mental retardation and inferior cognitive skills (Porac and Coren 1981).

The spontaneous bimanual movements of the children suggest that a system of differentiated hand use was not yet operational.³ An index of manual coordination that might have a diagnostic application is the placing of a rubber band around an object. Other observations, such as of a straight or a skewed direction in which a ball is kicked and an ability or inability to skip (or an ability to do two tasks simultaneously, e.g. to pick up something from the floor with one hand without spilling what is held in the other hand), could also be investigated as indications of how well or poorly the parts of the body function together and of how disequibrations might affect learning.

³Coren, Porac, and Duncan (1981) report significant shifts in hand, eye, and ear preferences between three- to five-year-old children and young adults. With the increase in right-sidedness, there were decreases in mixed handedness and in consistent left eye and ear preferences. (The incidence of mixed handedness was 25.5% for the children versus 13.5% for the adults.) Also significant was the greater congruence of the older than the younger sample in the five hand and foot pairings (i.e. of hand with foot and of each with eye and ear).

HANDEDNESS-SIDEDNESS INVENTORY

Name: _____

Date: _____

	Preferred hand/foot	Requested hand/foot	
Throwing a ball	_____	_____	| _____
Bouncing a ball	_____	_____	| _____
Kicking a ball	_____	_____	| _____
Hopping	_____	_____	| _____
Spinning a top	_____	_____	| _____
Rolling a marble	_____	_____	| _____
Stacking cubes:	Active hand _____	_____	_____
	Supportive hand _____	_____	_____
Threading beads:	Active hand _____	_____	_____
	Supportive hand _____	_____	_____
Winding string/yo-yo:	Active hand _____	*/ _____	*in/out
	Supportive hand _____	_____	
Drawing on slate board	_____		
Erasing board	_____		

Clap (upper hand): _____

Clasp (upper thumb): _____

Arm fold (upper arm): _____
 (grasping hand): _____

Writing name (preferred hand): _____

Pressing timer button/video remote control (preferred hand): _____ /

Viewing kaleidoscope/VT (preferred eye): _____ /

Placing rubber band around box (active hand): _____
 (supportive hand): _____

Replacing lid of box (active hand): _____
 (supportive hand): _____

Walking up/down stairs: _____ / _____ foot leading
 _____ / _____ feet/step

Skipping: Yes/no

REFERENCES

- Burt, C. (1958) *The Backward Child* (Fourth Edition). London: University of London Press.
- Cermak, S.A., E.J. Quintero, and P.M. Cohen (1980) Developmental age trends in crossing the body midline in normal children, *American Journal of Occupational Therapy* 34(5): 313-319.
- Clark, M.M. (1957) *Left-handedness: Laterality Characteristics and Their Educational Implications*, London: University of London Press.
- Coren, S., C. Porac, and P. Duncan (1981) Lateral preference behaviors in preschool children and young adults. *Child Development* 52(2): 443-450 (June).
- Gottlieb, G., C. Doran, and S. Whitley (1964) Cerebral dominance and speech acquisition in deaf children. *Journal of Abnormal and Social Psychology* 69: 182-189.
- Kósa-Jekkel, E. (1990) Lateral preference behaviour in atypical group of children. Paper presented at the IVth European Conference on Developmental Psychology. Stirling (August).
- Naidoo, S. (1972) *Specific Dyslexia*. London: Pitman.
- Oldfield, R.C. (1971) The assessment and analysis of handedness: The Edinburgh inventory, *Neuropsychologia* 9: 97-113.
- Orton, S.T. (1937) *Reading, Writing and Speech Problems in Children: A Presentation of Certain Types of Disorders in the Development of the Language Faculty*. London: Chapman and Hall.
- Porac, C., and S. Coren (1981) *Lateral Preferences and Human Behavior*. New York: Springer-Verlag.
- Tan, L.E. (1985) Laterality and motor skills in four-year-olds, *Child Development* 56: 119-124.

APPENDIX I

CLASSROOM EXAMPLES [*id est*]

Differences observed in the deaf children I taught were in skills they acquired either easily or arduously, rapidly or with delays. Salient qualities of some children were particularly differentiated in the following areas: (Asterisks identify those skills and qualities that seem to typify a more right-hemispheric mode of thinking.)

- language comprehension and fluency
- recitations of the alphabet, alphabetizing words and constructing sentences with printed words and phrases (with or without sign pictures)
- rote counting, versus formation of number sets*
- identification of opposites, versus identification of similarities*
- detection of missing, additional, or exceptional objects or details*
- copying designs (e.g. a three-dimensional box)*
- drawing lines through mazes (directly*, versus with back-tracks and erasures)
- weaving and sewing*
- creativity (not only in art but also with language)*
- humour and wit*

In these areas, there often seemed to be a night-and-day differentiation between what a child could and could not conceive. The children themselves clearly expressed both an assumption of their own abilities, a frustration (sometimes hiccups) about their inabilities, and an incredulity about other children's difficulties.

Descriptions of three children

"-est!" signed one child. She signed just '-est', the superlative suffix (a flamboyant 'hitchhiking' sign, almost identical to the sign for 'most'), and the Latin for 'is'. The referent was a very large shoe, one of the objects she was sorting into piles according to size. Her exclamation conveyed its essence -- the 'is' of it: It was the biggest, longest, and widest of the objects; the affix was the best single most comprehensive description. Such an inflection is known to be acquired late in the expressive language of hearing and deaf children, yet this child was only five years

old, in her second year at school and her second year of formal signing. How might her special precocity, and the specific salience of this sign, be explained? Why was she exceptional? What else might define what could be a particular mode of her thinking?

Another single sign she would use unequivocally with comprehension (because of the context, and her twinkle) was "Imagine...": an abstract concept, hardly what would be expected if the 'concrete thinking' stereotype of deaf children is believed. For her, drawing a line through a maze was easy but reciting the alphabet was difficult. She would be the first, if not the only, child to comment upon some little change in the classroom. Her perceptions and spontaneous expressions share a creativity, originality, and wit that other children with 'est' qualities can further illustrate.

Another child, later referred to a specialist for remediation in reading, was amused by the magic of letters and signs. His ability to see the 'is' of things extended beyond that -- to seeing what 'is' can become and what else may be. He invented a game of making one stick an 'I', then adding and shifting other sticks to make them become other letters (e.g. an 'L', a 'T', an 'E'), and discovered that an 'M' and a 'W' are the same but for our position relative to them. It was he who one day at snack composed a sign poem, instead of signing the rote sentence, "I want some milk, an orange, and a napkin, please" (with a strip of sign pictures as cues). His original version was to rhyme 'orange' with 'milk' and 'napkin' with 'please', signing each 'couplet' simultaneously with his right and his left hand.¹ He was instantly able to follow the lines and arrows of a sample on the blackboard to draw a three-dimensional cube, by connecting two squares with four diagonal lines. In mathematics, he perceived 'families' of numbers, e.g. of '3' and '4' and '7' -- but without heeding the critical importance of placement (thus succeeding in the addition problems with the addends either $3 + 4$ or $4 + 3$ but not in the subtraction problem when $7 - 4$ cannot be reversed as $4 - 7$). In his sequencing skills, he showed both success and failure: He correctly arranged cutouts of circus objects by size, elaborating the placements by spontaneously, and whimsically, combining all the objects so that the stands were beneath and the balls above the upside-down clowns. He made a single error in sorting 'before' and 'after' picture pairs, by placing the picture of a completed painting, not the partially painted picture, in the 'before' category, along with pictures

¹In American Sign Language, the handshape and movement of both couplet signs are identical; they differ only in the location parameter. ('Orange' is signed with a repeated hand squeeze at the mouth; for 'milk', the squeeze is made in neutral space, as if pulling on an udder. A flat-handed circular sign is made on the mouth for 'napkin', on the chest for 'please'.)

of new, whole, clean, and uneaten objects. (This error suggested that his operating rule was not of temporal order, from a first to a later state, but rather of diminution, from a whole and complete state to a partial and diminished state). His sequencing of pictures from stories read to the children and photographs of events experienced on field trips was inaccurate.

A puzzle about these two children was that she was right-handed, he left-handed. The other 'est child' to be described was ambidextrous.

This boy, diagnosed as 'multi-handicapped', also created sentences with two-handed signs (plus points and nods, and one-up-manship smiles). How he generated language to communicate with the few standard signs he had learned within weeks of being at school is shown in the following three examples. An ingenuity of his was signing 'red' with one hand and 'blue' with the other, then opening each hand to receive both a red and a blue block (the one-by-one system was indubitably less efficient -- and an impression he gave was that only his shoes kept him from using his feet as well). One other request translating as "I want both now" was his compounding the sign for 'raisin' with the sign for 'peanut' (a bit more difficult as 'raisin' is itself a two-handed sign). His economy, or poetry, was shown *par excellence* in his sign for the phrase "picture of a bird": He substituted the first 'chereme' for 'picture' with the sign for 'bird' and repeated 'bird' against his other hand for the second chereme of 'picture', i.e. producing 'bird-picture'. (He further reduced the movements of this sign ellipsis by simultaneously retaining the base handshape for 'picture' while superimposing the sign for 'bird' -- a single composite sign, perhaps transcribed Germanically as 'birdpicture'.)²

Comparisons

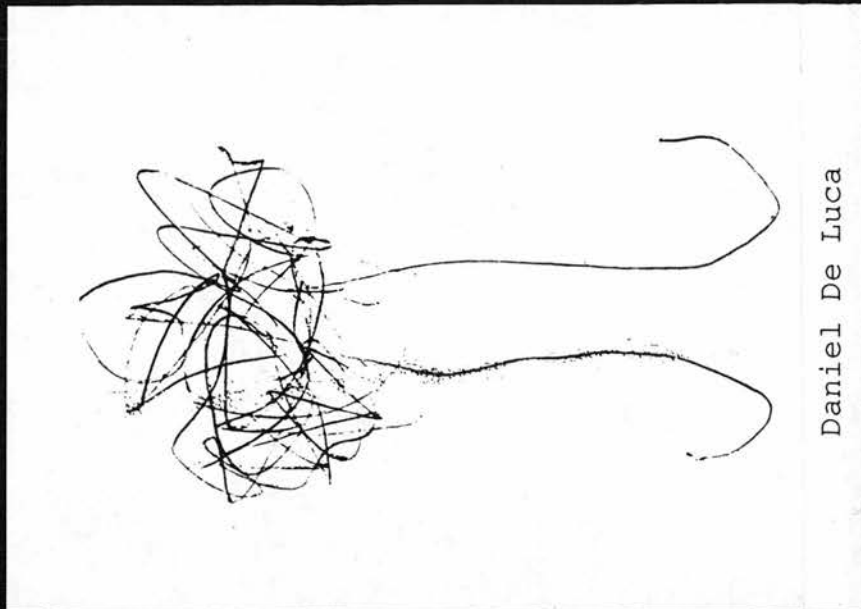
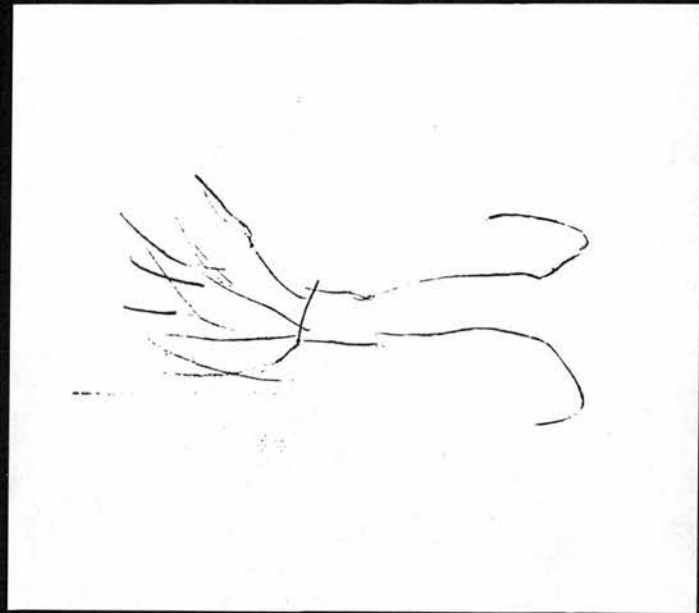
These (and other) skills and spontaneous inventions of 'est children' contrast to their deficits -- which, in turn, are the special skills of children who could be labelled 'id' (Latin for 'that'). These other children excel in language. For them, rote recitations, as of the alphabet and counting, are easy. Each particular is chained in a series to each other particular: 'that' plus 'that'... Simultaneous 'gestalts' elude them. (Their maze papers are smudged with erasures of back-tracks from blind alleys. Eggs fall through

²The last example of spontaneously invented two-handed signing is that of a child when she saw a photograph of herself receiving a prize: She signed 'shy' with one hand and 'afraid' with the other. (While 'shy' was made with an inward twisting motion at the cheek and 'afraid' with a straight fist-to-'five' movement in neutral space, the timing of them was synchronous.) It was thus that she expressed simultaneously her two co-occurring emotions.

the irregularly woven strips of *their* Easter baskets.)

Contrasts between these children correspond to predominantly different modes of consciousness and perception: The one, 'est', mode would seem to be associated with a right-hemispheric way of thinking (i.e. intuitively, imaginatively, holistically, simultaneously, spatially). The other, 'id', mode has characteristics of a left-hemispheric awareness (i.e. orderly, methodical, propositional, sequential, temporal, verbal thinking).

Although for some children these differences were absolute, for others they were relative, fluctuating or sporadic. They are of potential importance educationally, for diagnostic-prescriptive teaching and for appreciating strengths and well as weaknesses, and psychologically, for what can be learned about cognitive development. But the classroom examples are anecdotal and describe only some behavioural characteristics. To be substantiated, or refuted, thorough research was needed.



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